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MONTHLY REPORT

ON THE NUCLEAR FUEL MARKET

NUEXCO

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MONTHLY REPORT ON THE NUCLEAR FUEL MARKET
October 1985 No. 206

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To Our Readers

Nuexco will host a hospitality suite during the Atomic Industrial Forum's Annual Conference in San Francisco, California. The suite will be located at the Westin St. Francis Hotel, November 10-13. We look forward to seeing you there.

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NATURAL URANIUM AND SECONDARY MARKET CONVERSION

(All data as of September 30, 1985)

The **Exchange Value** is **$16.00** per pound U_3O_8, unchanged since last month. **Active supply** of natural uranium (U_3O_8 and UF_6) for spot or near-term delivery totals **2,095,000** pounds equivalent U_3O_8 as concentrates or UF_6, down 1,245,000 pounds since last month. The corresponding figure for **active demand** is **1,100,000** pounds, down 105,000 pounds. The spot and near-term **supply-demand ratio** fell to **1.9:1.**

The *Current Market Data* section of this Report lists four natural uranium sales transactions, involving a total of approximately 300,000 pounds U_3O_8 equivalent. All of the transactions reported this month involved deliveries in the near term, and three met the criteria for inclusion in the current Transaction Value calculation.

The **Transaction Value** is **$15.10** per pound U_3O_8, unchanged since last month. Transactions reported this month, all of which took place at prices less than the current Exchange Value, only added approximately 300,000 pounds to the calculation. Because that accounts for only about ten percent of the total material in the calculation, the new sales had only a negligible effect on the Transaction Value. The current Transaction Value includes 17 transactions involving a total of 2.7 million pounds U_3O_8 or equivalent UF_6, and covers a period of 4 months.

The **UF_6 Value** is **$44.50** per kilogram U in UF_6, unchanged since last month. Two of the transactions reported this month involved UF_6.

The **Conversion Value** is **$1.60** per pound U in UF_6, unchanged since last month. One conversion transaction, involving 100,000 to 300,000 pounds U as UF_6, is reported. No active demand for conversion is reported. Active supply of secondary market conversion services for delivery within three years totals 100,000 pounds U as UF_6; only a few conversion sellers are currently indicating an interest in the near-term market. The conversion value this month again exceeds the algebraic equivalent determined by the difference between the UF_6 Value and the Exchange Value. The UF_6 market continues to be led by UF_6 inventory sellers motivated by immediate sales, while the thin conversion market is characterized by highly discretionary supply for inconsistent demand.

The **Loan Use Charge Rate** is unchanged at **5 percent** per annum, as both lenders and borrowers continue to express their interest in doing business at that level.

* * *

The Exchange Value held steady at $16.00, and the UF_6 Value remained at $44.50 per kgU as UF_6, as market activity during the last week of the month reflected prices around those levels. Despite a general belief that prices are on the verge of upward movement, little new demand for spot or near-term material appeared in the market during September, so the anticipated movement had not materialized as of the last day of the month. *Active sellers* continue to offer their material at prices up to two percent above the current values, but recent transaction prices have been below the current Exchange Value and UF_6 Value. Buyers are generally interested in bargain prices below the current values, but, as has been the case for the past several months, some sellers continue to offer their material at prices well above competitive levels.

The UF_6 Value remains slightly less than the algebraic sum of the Exchange and Conversion Values. One seller, in order to liquidate one lot of UF_6 on short notice, discounted it substantially below the current UF_6 Value in order to conclude the sale. One buyer that had made an open request for offers concluded a purchase in the last week of the month at a price near the current Exchange Value.

The US dollar continued its decline against most currencies, reaching a four-year low against the Japanese yen. The decline again served to discourage sellers of spot or near-term material, while helping buyers intent on purchasing at dollar prices. One European buyer, in a deal arranged during the previous month, paid an effective price on delivery that was well below the price established at the time of contract signing, due to the subsequent strengthening of the buyer's currency relative to the dollar.

Two recent developments in the USA have already begun to induce a period of market uncertainty likely to persist for months; they were:

1. A federal court ruling that the USEC is invalid.
2. The declaration by the Secretary of Energy that the US uranium production sector is not viable.

Occurring almost simultaneously near the end of the month, the above events have fueled speculation of three kinds:

1. That various forms of relief will be granted to US producers;
2. That the invalidation of the USEC will free DOE customers, particularly overseas, to sign replacement contracts with Urenco and Eurodif;

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3. That a two-tiered market will arise, in which US-origin uranium will command a premium of $5 to $10 per pound U_3O_8.

The US producers' suit against DOE has yet to be resolved. Although the judge ruled in favor of the producers that the USEC contract is not valid, DOE has filed notice that it intends to appeal; furthermore, four more issues in the five-count dispute remain to be judged. The entire issue is ruled by political realities, so its outcome will be determined largely by non-economic factors.

While there still exists a general sentiment in the market that prices will rise soon, a pervasive uncertainty growing out of recent external events is becoming more influential in the behavior of market participants. The fact that most utilities still have substantial inventories is tempering sellers' optimism. Non-US sellers must continue to evaluate the pace of the dollar's movement relative to the change in market prices; some non-US sellers may choose to sell now rather than accept the currency risk. However, the size of the US federal deficit continues to qualify any currency speculation.

The increased probability that certain utilities will be forbidden to use South African uranium in power plants is forcing utilities and other entities holding South African-origin uranium to decide whether to sell that material or to continue holding it in inventory.

The development of the near-term market will be influenced by these factors and others. However, neither the extent, nor the direction, nor the timing of price movement is clear.

ENRICHED URANIUM AND SWUS

The Nuexco **SWU Values** as of September 30, 1985 are:

1. For **DOE origin,** a tails assay of 0.30 weight-percent U_{235}, for delivery by the end of FY86, and certifiable as excess, $85 per SWU, unchanged.

2. For **other** SWUs (includes DOE origin SWUs not certifiable as excess and non-DOE origin SWUs), for delivery by the end of calendar year 1986, $78 per SWU, down $3.

The SWU Value for DOE certifiable SWUs was unchanged and the value for SWUs of non-DOE or non-certifiable origin fell slightly, although the distinction between the two categories became blurred by the end of September. The September 19 ruling by a US District Court Judge in Denver that the USEC is null and void could, if it is upheld, nullify the market for certifiable SWUs, as that market is a creation of the USEC. However, as of the last day of the month, it was Nuexco's judgment that the implications of the court decision on the USEC were not yet clear enough to warrant a change in the interpretation of the pricing structure of the secondary market. (See separate article, this Report, page 4.)

Three secondary market SWU sales are reported this month, involving 50 to 100 thousand SWUs of both DOE and Eurodif origin. The demand for DOE-certifiable SWUs continues to be thin and sporadic in view of the heavy supply, and competition for significant quantities of SWU has been heated. Without the presence of a firm buyer, however, sellers had little opportunity to compete with one another, so there was little downward pressure on prices. Most transactions in the past few months have involved relatively small quantities. The non-DOE market has been relatively inactive in recent months, and that fact has made it difficult to assess changes in the SWU value. Steadily declining offers for substantial quantities of non-DOE SWU caused the value to be lowered slightly. However, if the USEC is in fact invalidated, the non-DOE market could revive rapidly in the coming weeks, and higher prices could be expected.

* * *

SWU PRICE FOR HIGH-ENRICED URANIUM

Nuexco's interpretation of the conditions of DOE's new "high assay charge" caused an incorrect analysis of the weighted average price for 93-percent enriched uranium in the *Pricing* section of Report 205 (September 1985, page 2). While DOE has not formally issued procedures for determining the average SWU price, the following equations provide a better representation of the cost structure, and are expected to be the basis for the official price determination.

The total SWU per kgU of enriched product is given by

$$S\ P = V_P - V_W - F\ P\ (V_F - V_W)$$

where V is the value function

$$V_x = (2x - 1)\ Ln\ (x\ [1 - x])$$

and

F P = Total kgU feed per kgU of enriched product
$= (X_P - X_W)\ /\ (X_F - X_W)$

X_P = product enrichment (weight-fraction U_{235})
X_F = feed enrichment
X_W = waste (tails) enrichment

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The Separative work per kilogram of product required to be performed above a given cutoff enrichment level "s" is given by

$$S/P_s = V_p - V_s - (x_p - x_s)(dV/dx)_s,$$

where $(dV/dx)_s$ is the derivative of the V function with respect to x, evaluated at s:

$$(dV/dx)_s = (2x_s - 1)\,(x_s[1 - x_s]) + 2\,\mathrm{Ln}\,(x_s\,[1 - x_s]).$$

The SWU price for high enriched uranium is the weighted average of the low enriched SWU price (currently $134) and the price of the SWU needed at above 10 percent ($492 after April 1, 1986):

$$\text{SWU price} = \frac{\$492\,(S/P_s) + \$125\,(S/P - S/P_s)}{S/P}.$$

As an example for 93-percent enrichment:

$$S/P = 235.550$$
$$S/P_s = 11.492$$

$$\text{SWU price} = \frac{\$492\,(11.492) + \$125\,(224.058)}{235.550} = \$142.80.$$

Nuexco's original price estimates assumed that the "high assay charge" would apply to the total number of SWUs required to enrich product from the cutoff point (10 percent) to the product assay. However, this total includes SWU performed at less than the cutoff enrichment level in order to "strip the tails," that is, reduce the enrichment of the waste stream down to the tails assay level. The DOE prices (and costs) are only increased for separative work performed above the cutoff enrichment level, so Nuexco's original price estimate of $184 per SWU for 93 percent incorporated too many SWU at the $492 price, and thus was too high. The enrichment cascade and the material flows are illustrated schematically in Figure 1.

DOE customers with USEC contracts have a contract ceiling price for SWU which is currently about $134. DOE is expected to charge these customers the ceiling price for the SWU needed above 10-percent enrichment, so the average SWU cost for USEC customers will be only about $125.44 for 93-percent enriched product.

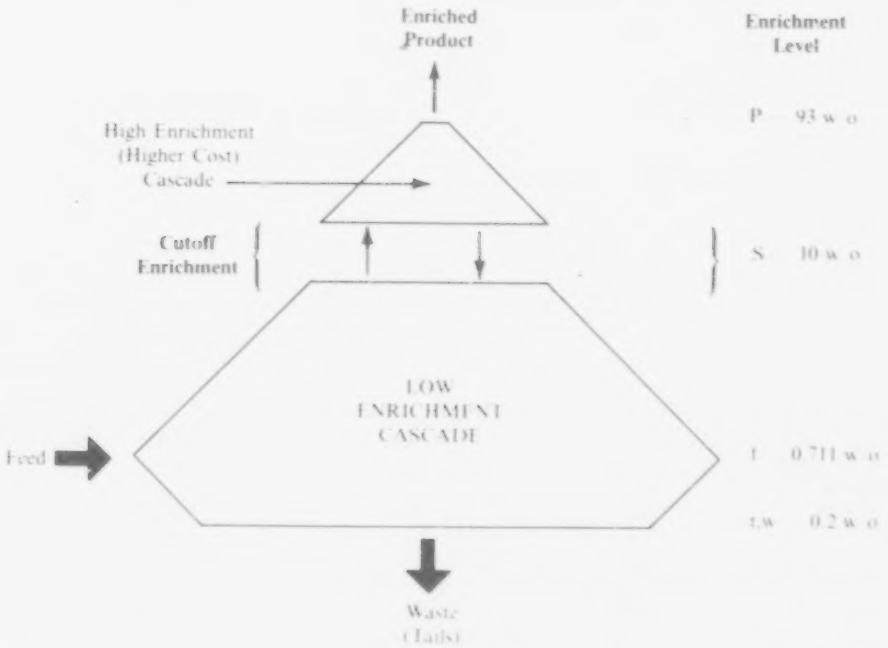

Figure 1

**CASCADE DIAGRAM
FOR HIGH-ENRICHED PRODUCT**

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Two September events in the USA could have profound effects on the entire front-end of the nuclear fuel cycle worldwide.

1. The US District Court in Denver, Colorado ruled that DOE's Utility Services enrichment contract (USEC) "amounts to a change in criteria under which enrichment services are to be performed." Because the contract was not submitted to Congress for review as required by law, Judge Carrigan declared the USEC null and void.

2. One week later US Secretary of Energy Herrington declared that the US uranium production industry was no longer viable.

INVALIDATION OF THE USEC

Judge Carrigan's ruling, first announced September 16 and amended September 19, addressed Count II of a five-count civil suit filed against DOE in December by three US uranium producers - Western Nuclear, Inc.; Energy Fuels Nuclear, Inc.; and Uranium Resources, Inc. The action had the support of other US producers, who later joined in the formation of an industry trade group called the Uranium Producers of America (UPA). That body has since assumed the leadership of the group's legal efforts. In Count II, the suit sought a declaration that the USEC is null and void and an order prohibiting DOE from adopting a generic enrichment contract without compliance with the Administrative Procedures Act. Report 197 of January 1985, on page 20, contains additional background information on the events leading up to the filing of the suit.

Under the Atomic Energy Act, DOE is required to establish written criteria describing terms and conditions for enrichment services. Furthermore, the adoption of any new criteria requires submission of the contract to Congress for review. In his order, Judge Carrigan stated that the critical issue regarding the USEC was that it "... [amounted] to new criteria governing enrichment." He cited three examples:

1. Existing criteria governing enrichment require that the primary DOE enrichment contract must be of a Fixed Commitment type, which the USEC clearly is not.

2. The USEC sets a ceiling price for enrichment services, which conceivably could prevent the government from recovering its costs. In 1973, for the same reasons, a similar provision which guaranteed a ceiling price was deleted from original criteria established in 1966.

3. Provisions in the USEC that base termination penalties on the period of notice that the customer gives DOE, rather than on recovery costs derived from DOE estimates of customer terminations, should be considered new criteria.

Thus, Judge Carrigan declared the contract null and void, and entered a summary judgment in favor of the producer group and against DOE with respect to Count II of the suit. DOE soon afterward filed a notice of its intent to appeal the ruling, a measure which extended to 60 days the period allowed for filing an appeal.

The four still-pending counts of the suit sought a wide range of relief.

Count I: requested a reimposition of the US embargo on foreign uranium. It asserted that, under the Atomic Energy Act [§161(v), 42 U.S.C. §2201(v), enacted in 1964], DOE is obligated to limit the enrichment of foreign uranium for domestic end uses so as to "assure the maintenance of a viable domestic uranium industry." The plaintiffs asked the court to take three actions under this count:

a. To declare the meaning of the term "viable" as employed in §161(v);

b. To order DOE to begin proceedings leading to the adoption of limits on enrichment of foreign-source uranium for domestic end use;

c. To order DOE to impose interim limitations on such enrichment, pending the outcome of such proceedings.

Some producers believe Herrington's declaration that the US industry is not viable will expedite a judgment on this count.

Count III: Because the surcharge for the variable tails assay option (VTAO) under the USEC tends to reduce uranium consumption, the suit sought to require DOE to allow customers to vary their tails assays at no charge.

Count IV: sought to prohibit the use of the federal government stockpile, either through sales of pre-production inventories or through over-feeding the enrichment cascades (to save power costs). Although such uses of the stockpile do not reduce uranium consumption in reactors, it can be argued that any reduction of USDOE stockpiles also reduces market opportunity for US producers.

Count V: sought judicial validation and enforcement of the principle that the US industry shall be maintained in a condition such that it shall be capable of supplying 100 percent of US requirements at any time, and under any hypothetical scenario for supply disruption. It asserted that the criteria for assessing the viability of the US industry [48 *Fed. Reg.* 45756 (Oct. 6, 1982)] were issued by DOE unlawfully in that the final regulation differed from that published for review so markedly as to be entirely different. It also asserted that the criteria selected by DOE failed to meet the requirements for, among other reasons, requesting relief under Section 262 of the Trade Expan-

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sion Act of 1962 (19 U.S.C. §1862) and Section 201 of the Trade Act of 1974 (19 U.S.C. §2251). The plaintiffs' main complaint with the adopted viability criteria was that they allowed for the inclusion of stockpiles to satisfy requirements, while the plaintiffs would prefer that viability depend on the industry's ability to supply 100 percent of requirements, even in the event of certain import supply disruption scenarios.

Of all the possible scenarios, complete abandonment of the laboriously constructed USEC seems the least likely. At the very least, such an action would severely impair DOE's already strained credibility with its customers, particularly those from overseas. Urenco and Eurodif probably would add to their already substantial gains at DOE's expense. Further penetration of the US market would become a distinct possibility as well. Because the establishment of new criteria requires Congressional review, DOE may simply submit the contract for that review. Such a tactic would provide time for DOE to perform the necessary lobbying in Congressional circles to ensure that the legality of the USEC is upheld. Other possible DOE responses include the restructuring of various provisions in the contract that have received the most criticism. In the meantime, however, DOE would like to continue business as usual. Customers may preempt that strategy by taking actions of their own, such as non-payment or non-acceptance of enrichment obligations incurred under the USEC.

NON-VIABILITY OF US URANIUM INDUSTRY

As expected and in spite of conflicting pressures from the US State Department, Energy Secretary Herrington announced on September 26, 1985 that the US uranium industry is not viable. Declaring that "I have taken steps to help the miners and millers in this important industry that is currently under a great deal of strain.", he:

1. Authorized DOE to offer a free VTAO each year to all customers that commit to buy 100 percent of their requirements from DOE over a rolling five-year period. It would save about $9 SWU for customers that select 0.30 weight-percent tails. This item was sought under the still-pending Count III of the producers' suit against DOE; perhaps now it has been rendered moot by the invalidation of the USEC.

2. Postponed for one year a DOE plan to feed some of its own uranium stockpile into enrichment plants. This item was also sought in the producers' suit (Count IV).

3. Asked the United States Trade Representative to examine the facts and implications of uranium imports and corresponding foreign trade and policy issues with a view to determining the appropriate courses of action under US trade laws. The Trade Representative will report back in three months.

One of the reasons given for Herrington's declaration of non-viability was the US mining industry's reported loss of more than $200,000,000 for 1984. That amount is a decline of $240,000,000 from 1983, when the industry reported a net profit of almost $40,000,000 and then-Energy Secretary Hodel declared the industry viable. Those figures do not take into account the producers that have already been forced out of the business. That DOE was able to wait so long to recognize what has been evident for at least three years indicates that the entire issue of the industry's viability is determined much more by political factors than by economic ones.

The declaration of non-viability has had, as yet, no direct effect. Sections of the legislation that require the Secretary of Energy to review the industry's viability (an amendment to a budget authorization) discuss what the Secretary could do or should do, but do not direct his actions in the event that he determines non-viability. For example, one section says:

"The Secretary . . . may determine . . . that source material [natural U] or special nuclear material [enriched U] . . . is being imported in such increased quantities as to be a substantial cause of serious injury, or threat thereof, to the US uranium mining and milling industry." If Herrington had made such a determination, then the US Trade Representative would be required to request an investigation by the US International Trade Commission. However, he did *not* make such a determination; he only asked the US Trade Representative to look into the matter and advise Herrington. In other words, Herrington asked for one investigation to determine whether he should initiate another. The US Trade Representative is supposed to report to Herrington in 90 days, so a decision on this point is likely in early 1986. And again, that decision more likely will be political rather than economic.

Another section says:

"If . . . the Secretary . . . determines that contracts . . . for . . . material from foreign sources . . . represent greater than 37½ percent of actual or projected domestic uranium requirements for any two-consecutive-year period," [That same point is listed as one of the criteria for viability, but was *not* cited as the basis for Herrington's declaration of non-viability.] *or*, if the Secretary determines that im-

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ports represent a threat to national security, then "the Secretary . . . shall request the Secretary of Commerce to initiate" an investigation under the Trade Expansion Act of 1962. If the government, as represented by the Secretary of Commerce, then determined that a threat to national security existed, trade barriers could be erected. Again, such a determination would be based almost solely on political considerations.

Conclusions

1. Any further actions by DOE will depend on political considerations.

   a. Will the US Trade Representative recommend an investigation by the US International Trade Commission? Only if the Reagan Administration wants him to do so.

   b. Will Herrington rule that imports threaten national security? Not unless Reagan wants him to do so.

   c. In either case, there is simply too little political benefit and too much political risk. Workers (or ex-workers) in larger industries that have been denied similar relief, such as steel, automobile manufacturing, shoe manufacturing, and semiconductors, might very well retaliate at the polls.

2. As yet neither the uranium nor SWU markets have moved in response to these two events. Buyers and sellers alike appear to have adopted a wait-and-see attitude. There is a commonly held view that, despite the complexity engendered by multiple contending interests, a prompt resolution of the uncertainties created by these related events is essential.

3. Because the interests of the affected parties vary so widely, no resolution can please everyone. Some US producers, having chosen to leave the uranium business, are primarily interested in mill tailings legislation. Other US producers, having decided to stay in the uranium production business, place highest priority on a foreign uranium embargo. Most US utilities oppose an embargo. Some DOE customers would like nothing more than the opportunity to get out of their DOE commitments. Other utilities want only to see the matter settled. DOE has substantial markets and cash flow at risk and hopes to reverse the invalidation of the USEC. The Administration has difficult foreign relations and commercial considerations with which to contend. It seems likely that a final resolution will require each to give up something in order to gain something.

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CURRENT MARKET DATA

September 30, 1985	Market Values	Active Supply[1] (thousands)	Active Demand[1] (thousands)
EXCHANGE VALUE	**$16.00** lb. U_3O_8	2,095	1,100
UF_6 VALUE	**$44.50** kgU		
CONVERSION VALUE	**$1.60** lb. U as UF_6	100	0
SWU VALUES			
DOE origin, certifiable as excess, 0.3 tails assay delivery by the end of FY86	**$85** SWU		
Other SWUs (non-DOE or non-certifiable) delivery by the end of calendar year 1986	**$78** SWU		
LOAN USE CHARGE RATE	5% annum	2,000	500

TRANSACTION VALUE	$/lb. U_3O_8	Millions of Pounds	Number of Transactions	Number of Months
	15.10	2.7	17	4

[1]Supply and demand tables in the *Current Market Data* section of this Report detail the numbers for each category.

DEFINITIONS

1. The **Exchange Value** is Nuexco's judgment of the price at which transactions for significant quantities of natural uranium concentrates could be concluded as of the date indicated.
2. The **UF_6 Value** is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of natural uranium hexafluoride could be concluded as of the date indicated.
3. The **Conversion Value** is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of conversion services could be concluded in the secondary market as of the date indicated.
4. The **SWU Values** represent Nuexco's judgment of the price at which transactions for the sale of significant quantities of SWUs of stated origin for delivery in the specified time period could be concluded as of the date indicated.
5. The **Loan Use Charge Rate** is Nuexco's judgment of the annual interest rate at which uranium loans could be concluded as of the date indicated.
6. The **Transaction Value** is a weighted average price of recent natural uranium sales transactions. The calculation is based on prices paid in:
   a. Transactions closed within the previous three-month period for which delivery is scheduled within one year of the transaction date;
   b. At least ten transactions;
   c. Transactions involving a sum total of at least 2 million pounds U_3O_8 equivalent.

   The sample time is extended as necessary to include these minima. Other currencies are converted to US dollars using conversion rates in effect on or near the transaction date.

DERIVATIONS AND COMMENTS

1. All Market Values are based on:
   a. Data from recently completed transactions.
   b. Data from pending transactions.
   c. Firm bids to buy or borrow, and firm offers to sell or lend.
   d. Prices purchasers or rates borrowers have expressed a willingness to pay, but for which Nuexco is not aware of firm bids to buy or borrow, and prices sellers or rates lenders have expressed a willingness to offer, but for which Nuexco is not aware of firm offers to sell or lend.
2. Prices associated with deliveries under old or renegotiated contracts or other than arm's-length transactions are not considered in the determination of these Market Values.
3. In the determination of the Conversion Value, Nuexco does not consider transportation charges other than those customarily provided by primary suppliers of conversion services.
4. The prices of conversion services or SWUs delivered under long-term contracts with primary suppliers are not considered in the determination of either the Conversion Value or SWU Value.
5. For the DOE SWU Values, Nuexco converts SWU prices at varying tails and product assays to equivalent SWU prices at a tails assay of 0.30 weight-percent U_{235} and a product assay of 3.0 weight-percent U_{235}, assuming feed costs corresponding to the Nuexco Exchange and Conversion Values determined as of the same date.
6. In calculating the Transaction Value, Nuexco does not account for the price of uranium delivered in connection with contracts which call for "market price" mechanisms. This exclusion applies particularly to contracts in which delivery prices are expressed as a function of future Exchange Values or any other indeterminant variable. Also excluded from the calculation are any other transactions in which the delivery price is defined in such a way that it cannot currently be determined.

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CURRENT MARKET DATA

EXCHANGE VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1,2]

Country (currency)	per lb. U_3O_8 in Concentrates			per kg. U in Concentrates		
	This Month (Sep. 30, 1985)	Last Month (Aug. 31, 1985)	12 Months Ago (Sep. 30, 1984)	This Month (Sep. 30, 1985)	Last Month (Aug. 31, 1985)	12 Months Ago (Sep. 30, 1984)
Australia (dollar)	22.79	22.74	20.96	59.25	59.13	54.49
Belgium (comm. franc)	866.27	899.89	1,072	2,252	2,339	2,786
Canada (dollar)	21.98	21.78	23.05	57.15	56.63	59.92
Finland (markka)	91.90	94.45	110.06	238.92	245.55	286.14
France (franc)	130.61	135.82	162.04	339.56	353.11	421.26
FRG (mark)	42.94	44.46	53.05	111.64	115.58	137.91
Italy (lira)	29,154	29,840	32,901	75,795	77,576	85,535
Japan (yen)	3,458	3,793	4,280	8,991	9,862	11,126
Netherlands (guilder)	48.28	50.09	59.50	125.52	130.22	154.70
South Africa (rand)[2]	40.30	45.71	29.17	104.78	118.85	75.83
Spain (peseta)	2,611	2,613	2,959	6,789	6,795	7,693
Sweden (krona)	128.51	132.45	149.83	334.11	344.34	389.52
Switzerland (franc)	35.15	36.45	43.68	91.38	94.77	113.57
UK (pound)	11.37	11.43	14.05	29.55	29.72	36.52
US (dollar)	16.00	16.00	17.50	41.60	41.60	45.50

TRANSACTION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1,2]

Country (currency)	per lb. U_3O_8 in Concentrates			per kg. U in Concentrates		
	This Month (Sep. 30, 1985)	Last Month (Aug. 31, 1985)	12 Months Ago (Sep. 30, 1984)	This Month (Sep. 30, 1985)	Last Month (Aug. 31, 1985)	12 Months Ago (Sep. 30, 1984)
Australia (dollar)	21.51	21.46	19.82	55.92	55.80	51.53
Belgium (comm. franc)	817.54	849.27	1,013	2,125	2,208	2,635
Canada (dollar)	20.74	20.56	21.80	53.93	53.45	56.67
Finland (markka)	86.73	89.14	104.09	225.48	231.74	270.61
France (franc)	123.27	128.18	153.24	320.46	333.25	398.39
FRG (mark)	40.53	41.96	50.17	105.36	109.08	130.42
Italy (lira)	27,514	28,161	31,115	71,531	73,213	80,892
Japan (yen)	3,264	3,580	4,047	8,486	9,307	10,522
Netherlands (guilder)	45.56	47.27	56.27	118.46	122.89	146.30
South Africa (rand)[2]	38.04	43.14	27.58	98.88	112.16	71.71
Spain (peseta)	2,464	2,466	2,798	6,407	6,412	7,275
Sweden (krona)	121.29	125.00	141.70	315.31	324.97	368.38
Switzerland (franc)	33.17	34.40	41.31	86.24	89.44	107.40
UK (pound)	10.73	10.79	13.29	27.89	28.05	34.54
US (dollar)	15.10	15.10	16.55	39.26	39.26	43.03

[1]Calculated using currency exchange rates published in the *Wall Street Journal* on September 30, 1985.
[2]South African rand values (financial rand) based on rates published September 27, 1985.

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CURRENT MARKET DATA

CONVERSION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1] [2]

Country (currency)	per lb. U as UF_6			per kg. U as UF_6		
	This Month (Sep. 30, 1985)	Last Month (Aug. 31, 1985)	12 Months Ago (Sep. 30, 1984)	This Month (Sep. 30, 1985)	Last Month (Aug. 31, 1985)	12 Months Ago (Sep. 30, 1984)
Australia (dollar)	2.28	2.27	1.20	5.02	5.01	2.64
Belgium (comm. franc)	86.63	89.99	61.24	190.98	198.39	135.00
Canada (dollar)	2.20	2.18	1.32	4.85	4.80	2.90
Finland (markka)	9.19	9.45	6.29	20.26	20.82	13.87
France (franc)	13.06	13.58	9.26	28.80	29.94	20.41
FRG (mark)	4.29	4.45	3.03	9.47	9.80	6.68
Italy (lira)	2,915	2,984	1,880	6,427	6,578	4,145
Japan (yen)	345.87	379.33	244.56	762.51	836.27	539.16
Netherlands (guilder)	4.83	5.01	3.40	10.64	11.04	7.50
South Africa (rand)[2]	4.03	4.57	1.67	8.89	10.08	3.67
Spain (peseta)	261.14	261.35	169.09	575.71	576.18	372.78
Sweden (krona)	12.85	13.25	8.56	28.33	29.20	18.88
Switzerland (franc)	3.51	3.65	2.50	7.75	8.04	5.50
UK (pound)	1.14	1.14	0.80	2.51	2.52	1.77
US (dollar)	1.60	1.60	1.00	3.53	3.53	2.20

SWU VALUES AND UF_6 VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1] [2]

Country (currency)	DOE SWU Delivery by the End of FY86 (September 30, 1985)	Non-DOE SWU Delivery by the End of CY86 (September 30, 1985)	UF_6 Value per kg. U in UF_6 This Month (September 30, 1985)	UF_6 Value per kg. U in UF_6 Last Month (August 31, 1985)
Australia (dollar)	121.08	111.11	63.39	63.26
Belgium (comm. franc)	4,602	4,223	2,409	2,503
Canada (dollar)	116.77	107.16	61.13	60.59
Finland (markka)	488.23	448.02	255.60	262.69
France (franc)	693.88	636.73	363.27	377.76
FRG (mark)	228.13	209.34	119.43	123.65
Italy (lira)	154,883	142,128	81,086	82,991
Japan (yen)	18,374	16,861	9,619	10,550
Netherlands (guilder)	256.49	253.37	134.28	139.31
South Africa (rand)[2]	214.11	196.47	112.09	127.14
Spain (peseta)	13,873	12,730	7,262	7,269
Sweden (krona)	682.73	626.51	357.43	368.38
Switzerland (franc)	186.73	171.35	97.76	101.39
UK (pound)	60.39	55.42	31.62	31.80
US (dollar)	85.00	78.00	44.50	44.50

[1]Calculated using currency exchange rates published in the *Wall Street Journal* on September 30, 1985.
[2]South African rand values (financial rand) based on rates published September 27, 1985.

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CURRENT MARKET DATA

RECENT TRANSACTIONS[1]

Uranium Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity (thousands of pounds, U_3O_8 equivalent)	Approximate Price as Percent of Current Exchange or UF_6 Value	Seller	Buyer	Remarks
3571	1985	50-100	94	European Producer	European Utility	
3570	1986	50-100	less than 101	Trader	European Utility	UF_6.
3569	1985	101-300	98	US Fabricator	US Utility	UF_6.
3568	1985	50-100	96	US Producer	US Producer	Market-related price.

Secondary Market Conversion Services

Nuexco Transaction Number	Delivery Period	Approximate Quantity (thousands of pounds, U equivalent)	Approximate Price as Percent of Current C.V.	Seller	Buyer	Remarks
3572	1986	101-300	94	US Utility	US Utility	

Enrichment Services
Secondary Market Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity[2] (thousands of SWUs)	Approximate Price[3] as Percent of Current SWU Value[4]	Seller Group	Buyer Group	SWU Origin	Remarks
3573	1986	less than 50	100	European Entity	European Utility	DOE	
3567	1986	less than 50	R[5]	European Entity	R[5]	Eurodif	
3563	1986	less than 50	100	Trader	US Utility	DOE	

[1] Transactions listed are not limited to those in which Nuexco was involved, but also include others of which Nuexco is aware.
[2] If tails assay is unknown or unspecified, Nuexco's calculation of SWU quantity assumes 0.30 w/o tails assay.
[3] Price is not normalized to 0.30% tails assay.
[4] Refers to SWU Value that corresponds to SWUs included in transaction. When prices and SWU values are expressed as discounts (e.g., X dollars less than DOE's USEC base price at time of delivery), the percentage refers to the ratio of the *discounts*, not the ratio of the prices.
[5] The notation *R* means that Nuexco either does not know, or that Nuexco has restricted that information to protect client confidentiality.

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URANIUM SUPPLY
(September 30, 1985)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Available for Sale:			
ACTIVE			
2654*	300	700 per year	UF_6
2711*	175	—	U_3O_8 or UF_6
2728	200	500 per year	1986-90
2746*	180	—	UF_6e
2763*	40	—	
2774*	200	—	
2793*	500	—	
2814	500	500	UF_6
2263*	—	400 per year	1987 on
2625	—	250 per year	1987-89
2680	—	250 per year	1986-92
2778*	—	220 per year	1987-90
TOTAL:	2,095		
INACTIVE			
1860	250	1,000 per year	UF_6
2335	275	—	
2336	250	250 per year	1985-94
2389*	75	75 per year	1986-90
2483	545	—	
2553	300	—	
2705A*	200	—	UF_6
2777*	250	—	
2804*	100	—	
2297	—	200 per year	1986-89
TOTAL:	2,245		

*New or revised since last month.
[1]Measured from the date of this Report.
[2]For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.
Projects removed since last month: 2191, 2623, 2668, 2736.

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CURRENT MARKET DATA

URANIUM DEMAND
(September 30, 1985)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Inquiries to Purchase:			
ACTIVE			
2743*	300	—	
2748*	200	—	
2775	200	—	
2784	100	—	
2785*	300	—	U_3O_8 or UF_6
2217	—	1,000 per year	1989-95
2507	—	600	1987-89
2681*	—	500 per year	UF_6 or U_3O_8; 1987-88
2741	—	600	
2753*	—	200	1987
2758	—	500	UF_6
2796*	—	175 per year	1988-92
TOTAL:	1,100		
INACTIVE			
2548	290	—	
2586*	300	300 per year	1987-90
2676*	200	—	
2718	250	350	
2767*	200	—	UF_6
2643	—	150 per year	1987 on
2733*	—	500 per year	1987-95
TOTAL:	1,240		

*New or revised since last month.
[1]Measured from the date of this Report.
[2]For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.
Projects removed since last month: 2414, 2576, 2590, 2636, 2694, 2757.

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LOAN SUPPLY AND DEMAND
(September 30, 1985)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U3O8) Within 1 Year	Beyond 1 Year	Remarks
Available for Loan:			
ACTIVE			
1938	2,000		UF6
TOTAL:	2,000		
INACTIVE			
2036	500		
2483	550		
2667	800		
TOTAL:	1,850		
Inquiries to Borrow:			
ACTIVE			
2606	500		
TOTAL:	500		

*New or revised since last month
[1] Measured from the date of this Report
Projects removed since last month: 2469

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CURRENT MARKET DATA

CONVERSION SUPPLY AND DEMAND
(September 30, 1985)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U as UF6) Within 3 Years	Beyond 3 Years	Remarks
Available for Sale:			
ACTIVE			
2051*	100	—	
TOTAL:	100		
Inquiries to Purchase:			
INACTIVE			
2587*	35	—	
2623*	1,000	—	
2709*	50	—	1986-91
2724	—	375	1989-93
TOTAL:	1,085		

*New or revised since last month.
[1]Measured from the date of this Report.
Projects removed since last month: 2511, 2529, 2576, 2617, 2725.

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CURRENT MARKET DATA

SWU SUPPLY AND DEMAND
(September 30, 1985)

Nuexco Project Number	Delivery Period[1] (Thousands of SWUs) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Available for Sale:			
ACTIVE			
2410A	350	—	
2607	200	—	
2705*	350	—	
2571	—	55	1987
TOTAL:	900		
INACTIVE			
2359	—	200	
2378	—	120	1988
2510	—	50	
2652	—	25	1986
TOTAL:	0		
Inquiries to Purchase:			
ACTIVE			
2400	—	150	1987-90
2519	—	30 per year	1987 on
2578*	125	—	
2742	10	—	
2747*	—	150	1988-89
2752*	65	—	
TOTAL:	200		
INACTIVE			
2500	—	170	1988
2512	—	15 per year	1987 on
TOTAL:	0		

*New or revised since last month.
[1]Measured from the date of this Report.
[2]For delivery within one year. This category excludes SWUs deliverable within one year under other than spot or near-term contracts.
Projects removed since last month: 2595, 2597, 2624, 2668, 2684.

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RAW MATERIALS

THE CIGAR LAKE PROJECT

Introduction

Canada's Cigar Lake uranium deposit, the largest high-grade uranium deposit ever discovered, is located in northern Saskatchewan, 115 kilometers northeast of the Key Lake mine. Continuing the pattern that has seen each major uranium discovery in the province surpass the previous ones, an unparalleled combination of high grade and resource size make Cigar Lake the most exciting uranium discovery in recent years. Preliminary production plans call for annual output of 12,000,000 pounds U_3O_8, approximately the same as that of Key Lake, presently the world's largest uranium production center, but Cigar Lake has the potential to surpass that level at will.

The Cigar Lake uranium deposit was discovered May 9, 1981; the very first hole drilled revealed high-grade uranium associated with nickel-cobalt arsenides. Each season's drilling revealed additional reserves. Drill-indicated reserves in the main mineralized pod have been calculated at 285 million pounds of an average grade of 14 percent U_3O_8, and inferred reserves in its western extension total 100 million pounds of an average grade of 4.7 percent U_3O_8. Technically, reserves are based on a 0.1-percent cutoff grade, but the estimates are insensitive to the choice of cutoff grade. The deposit is at an average depth of 430 meters, has an indicated length of at least 1,850 meters, and remains open to the west.

The ore deposit and immediate surrounding property are controlled by the Cigar Lake Mining Corporation (CLMC), a joint operating company formed May 16, 1985. Ownership of CLMC is the same as in the Waterbury Lake joint venture: Saskatchewan Mining Development Corporation (SMDC), 50.75 percent; Cogema Canada Limited, 32.625 percent; Idemitsu Uranium Exploration Canada Ltd., 12.875 percent; and Corona Grande (a wholly owned subsidiary of Cogema), 3.75 percent (acquired from Reserve Oil & Minerals Corporation). Operating out of Saskatoon, Saskatchewan, CLMC's primary function will be to identify a suitable mining and milling program for the deposit. Figure 2 shows the location of the Cigar Lake deposit.

Exploration Events

The Cigar Lake discovery climaxed the series of geologic and exploration events in Saskatchewan that began in the late 1960s. Early exploration conducted by the Canadian Kelvin group included geophysical and geotechnical surveys over a large portion of the vast 900,000-acre Waterbury Lake claim block. A few anomalous areas had been identified, but not defined, on the Waterbury Lake acreage. Asamera Oil Corporation became the project operator in 1976. Asamera made a limited contribution to regional exploration of the lands during the next two and one-half years, conducting geological surveys and drilling several hundred holes. Their effort culminated in the discovery and delineation of the Dawn Lake deposits.

The original Canadian Kelvin claim block was later divided into three separate blocks to accommodate the split of the joint venture group. Cogema Canada Limited (then SERU Nucleaire) acquired a 32.625-percent interest in the 230,000-acre Waterbury Lake block in late 1979 and became operator of the project in January 1980. Cogema immediately renewed exploration efforts throughout the claim block. Previously determined anomalies, including those at Cigar Lake, received top priority and exploration work began in those areas.

One such anomaly was situated on an arm of Waterbury Lake near Cigar and Tibia Lakes. Cogema detailed the area with airborne and ground geophysical surveys, using the most advanced instruments available for deep penetration of the cover rocks. At least two strong graphite gneiss conductor zones, trending almost due east-west, were identified in the basement rocks at depths exceeding 400 meters. Geophysical methods also determined that each zone is closely associated with prominent northeast-southwest and east-west faulting. One zone crosses the south end of Cigar Lake; the other, about one kilometer (km) to the north, tends to parallel the south shore of Tibia Lake. The results of further geochemical surveys indicated the existence of radiometric anomalies in sediments of the three nearby lakes, suggesting that radon gas, originating from deep-seated uranium mineralization, may have reached the surface by ascending along zones of weakness created by the faulting.

Cogema first identified the area for evaluation by drilling based on an exploration model. The model was formulated by analyzing information acquired through a variety of techniques, including the adaptation of certain characteristics of earlier models developed (both *a priori* and *ex post facto*) for deposits at Key Lake, Dawn Lake, Midwest Lake, and others. The first hole drilled on the Cigar Lake prospect (the 15th hole drilled by Cogema on the Waterbury Lake claims) was collared in April 1981. Mineralization was encountered on May 9 at a depth of 428 meters. The hole penetrated an ore zone measuring 13.1 meters thick with an average grade of 1.82 percent U_3O_8. Fourteen of the next 16 holes drilled encountered ore zones of up to 17 meters thick and at grades of 7.20 percent to 24.08 percent U_3O_8.

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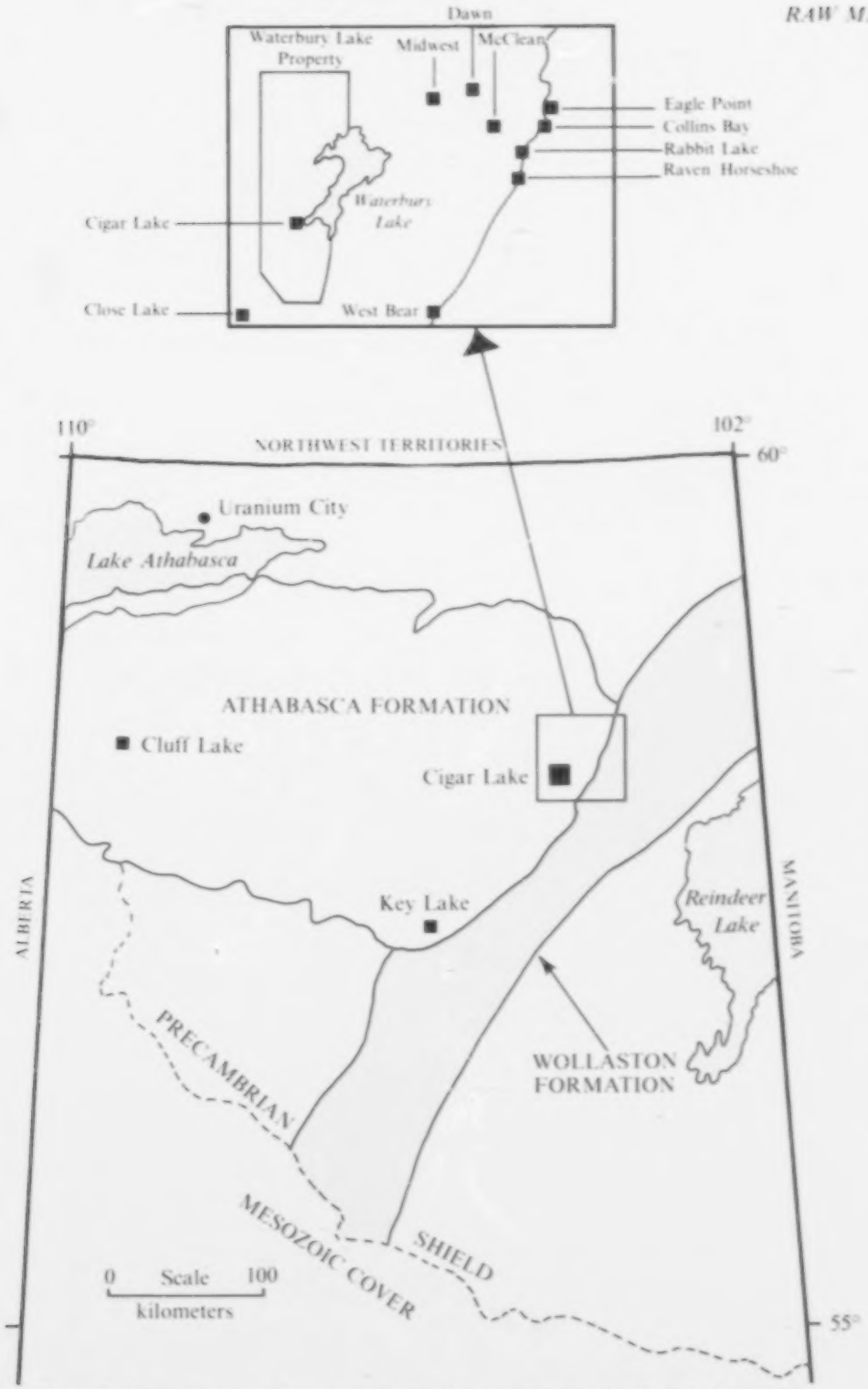

Figure 2. Location map of northern Saskatchewan, showing the Cigar Lake uranium deposit and others in the district.

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Cogema also pursued the anomaly at Tibia Lake, with considerably different results. The exploration model generated for the prospect showed many of the same favorable characteristics as the model for Cigar Lake. Fifteen holes were drilled, of which eleven were barren and four were mineralized. The most significant mineralization encountered was a zone at a depth of 470 meters. It was four meters thick and averaged about 1 percent U_3O_8. Overall, the mineral zone was found to be erratic in occurrence within a drilled-out area of 150 meters by 50 meters. The Tibia Lake prospect has been temporarily abandoned in favor of other promising targets in the vicinity.

The Ore Deposit

The Cigar Lake deposit was almost completely delineated by the end of the 1984 drill campaign. Some additional drilling was done in early 1985 to complete delineation of the main zones of mineralization. (Figures 3 and 4 show the drilling of an incline hole and preparation for winter drilling, respectively.) A total of 165 holes were drilled on the deposit over its east-west strike length of 2,000 meters and width of 25 to 105 meters. Uranium mineralization appeared in 111 holes, highlighted by a number of extremely high-grade ore intercepts. For example, the core from one hole assayed an average 37.70 percent U_3O_8 over a thickness of 19 meters. (Figure 5 shows core samples.) Further drilling on the ore deposit probably will not be required, except to provide additional information in support of development efforts.

Figure 3. Drilling an incline hole.

Figure 4. Drill rig prepared for winter drilling.

The ore body shows good continuity throughout the entire length. However, it is divided into three main zones of mineralization, a circumstance conducive to extraction purposes. The most prolific portion, ore zone 122, lies at the eastern end between drill lines 7+00E and 10+50E. That area of 350 meters along strike contains approximately 165 million pounds U_3O_8 at a grade of 20 percent to 25 percent. The next important portion, comprised of zones 3 and 4, lies between drill lines 4+00E and 7+00E, an area of 300 meters containing approximately 120 million pounds U_3O_8. Figure 6 shows the interrelationship of the areas.

The third area of interest includes the entire western portion of the deposit from drill line 4+00E to drill line 7+00W, a distance of 1,100 meters. The ore body varies from one to four meters in thickness to the west and the

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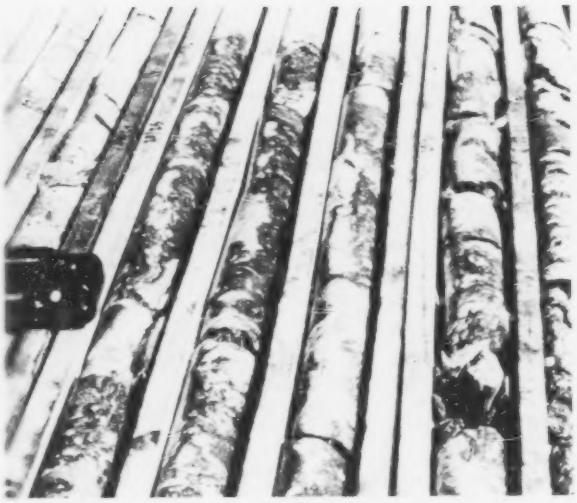

Figure 5. Drill core samples.

grade averages 4.7 percent U_3O_8. The zone contains approximately 100 million pounds of inferred ore. Present plans do not include the western extension in an exploitation schedule. However, eventual exploitation should not be ruled out at this early stage of project planning.

Ore body continuity primarily pertains to basal characteristics of the mineralized zone. The basal contact is the unconformity; the ore is situated on top of the basement ridge which varies in height from three meters to thirty meters. Thus, the deposit is 420 to 440 meters in depth, relatively flat-lying, or concave over the full extent of 2,000 meters along the ridge. The ore thickens in the primary zones to about 20 meters, and the upper ore limit is about 410 meters from the surface.

The unconformity separates metasediment basement rocks of Lower Proterozoic age from overlying Athabasca sandstone of Middle Proterozoic age. Most ore occurs in the lower Athabasca sandstone, representing the first major deposit in the district where sandstone is

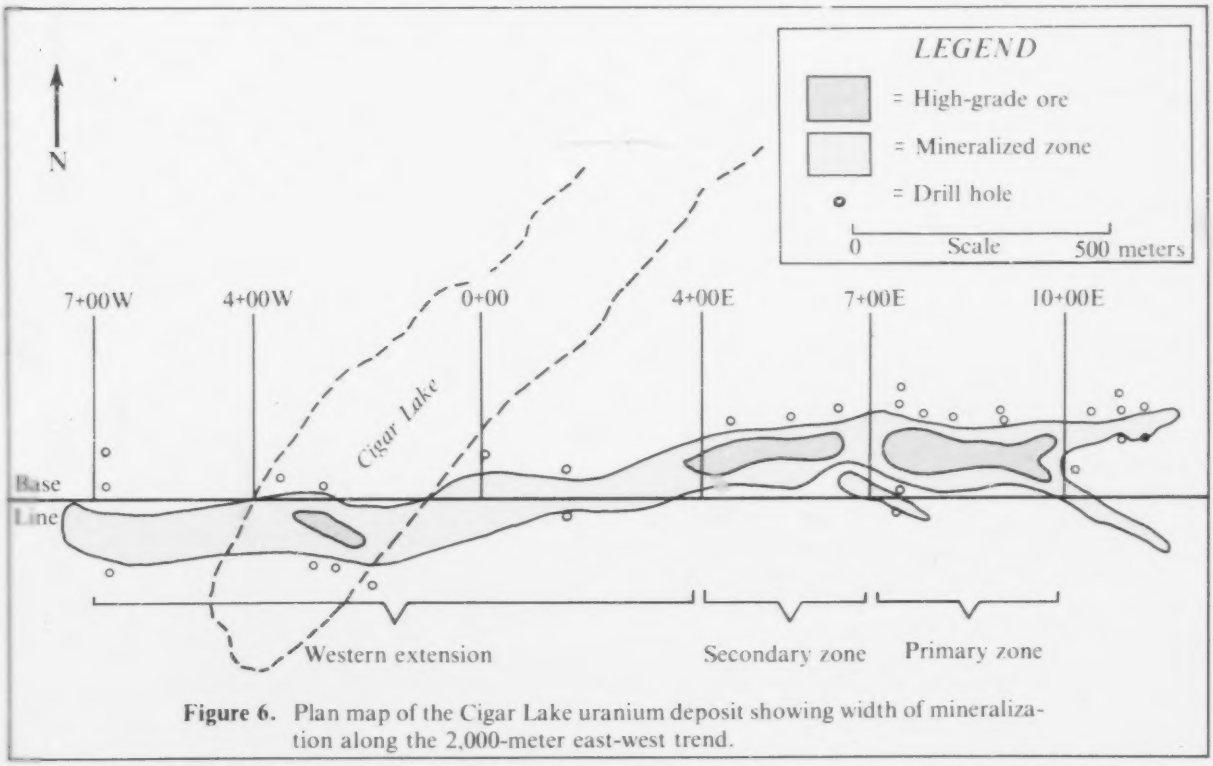

Figure 6. Plan map of the Cigar Lake uranium deposit showing width of mineralization along the 2,000-meter east-west trend.

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the principal host rock. Mineralization in the basement rocks is limited to inconsistent pods along the unconformable contact. It may thicken to two or three meters locally, and develop strongly along faults, veinlets, and fracture zones. High-grade ore (in excess of 50 percent) is common in this environment. However, the tonnage in the basement rocks is relatively small and will not be an important part of the overall project economics.

Additional mineralization occurs as "perched pods" in the highly altered sandstone and quartz zones of the upper sandstone sequence. The mineralization has accumulated along fault zones where alteration (hydrothermal activity) was more intense and the environment more conducive to mineral deposition. Such zones may occur up to 200 meters above the unconformity. The mineral content averages about one percent to four percent U_3O_8. The relatively low grade and limited tonnage in the perched pods make it unlikely that they will be mined. Figure 7 is an idealized cross-section through the ore deposit illustrating these features.

Mineralization

The mineralizing process at Cigar Lake was directly associated with extensive hydrothermal solution activity resulting in rather complete rock alteration. The mineralization is the center-zone of the alteration process. It was precipitated (or recrystallized) in the Athabasca sandstone from migrating fluids in the presence of a reducing environment. This process was associated with the underlying presence of the graphitic gneiss conductor in the basement rock. Intense alteration has caused depletion of graphite from the gneiss zone, affecting basement rock characteristics as much as 100 meters below the unconformity. The Athabasca sandstone is altered at least 200 meters above (Figure 7).

The extent of rock alteration is a measure of the clay content. The mineralized zone and the massive clay which completely encloses it has a clay content of 30 percent to 80 percent. It is light grey to dark green and generally consists of illite and iron-rich kaolinite, both associated with siderite (areas 1 and 2 in Figure 7). The zone is soft and may prove to be totally incompetent for conventional mining procedures. Immediately above that zone is a halo of alteration in the lower Athabasca sandstone unit, containing about 30 percent clay. Overall, the zone is friable and locally unconsolidated due to the removal of quartz cement through the alteration process (area 3). Further above lies a broad band of alteration recognized as the quartz zone, wherein the sandstone has undergone irregular but extensive silicification. The clay content is essentially nonexistent throughout the zone; the rock is brittle, hard, and abrasive (area 4). The last zone consists of grey sandstone with further loss of siliceous cement and increasing clay content. The sandstone is grey in color because of the presence of finely disseminated iron sulfides (area 5). The zone is soft and locally unconsolidated. Above that zone, the Athabasca is mostly unaltered, appearing pink in color (area 6).

Alteration in the basement rock was even more extensive. The massive clay zone at the unconformity and underlying the ore deposit is 80 percent clay consisting of alumino-magnesian chlorites and magnesian illite (areas 1 and 2). The alteration process was so complete that the original texture of the metasediments was destroyed. The clay content decreases with depth, becoming grey to green illite-chlorite (area 3a). The original rock texture is preserved near the final stages of alteration at a depth of about 100 meters below the unconformity (area 8).

The mineralizing process, which appears to have transpired in three distinct phases of accumulation, occurred along with the alteration process. Phase 1 is the most important, representing the bulk of all uranium present. Uraninite (uranium oxide) occurs as the principal metal present in the main ore deposit at the unconformity. The uranium content is extremely high, commonly exceeding 50 percent U_3O_8 over a thickness of one meter to 19 meters. Associated minerals present include nickel and cobalt arsenides. The host rock is the lower Athabasca Sandstone unit; the gangue minerals are mainly iron and magnesian illites.

Pitchblende (uranium oxide) is the main uranium mineral deposited during Phase 2. It is associated with copper sulfides in the iron-rich kaolinite of the massive clay zone and the alumino-magnesian chlorites in the basement rock, and is possibly the first evidence of recrystallization and remobilization of the uranium (see Figure 7).

Phase 3 included the introduction of coffinite (uranium silicate) and pitchblende in close association with nickel-cobalt arsenides. These were disseminated throughout much of the deposit, especially along the mineral trend, in veinlets and along faults in the basement. Phase 3 is essentially remobilized mineralization making up most of the mineralization present in the perched pods of the upper altered formations. Overall, the associated metal values tend to be rather consistent: 0.70 percent copper; 1.16 percent lead; 0.04 percent zinc; 0.14 percent molybdenum; 0.96 percent nickel; 0.15 percent cobalt; 1.67 percent

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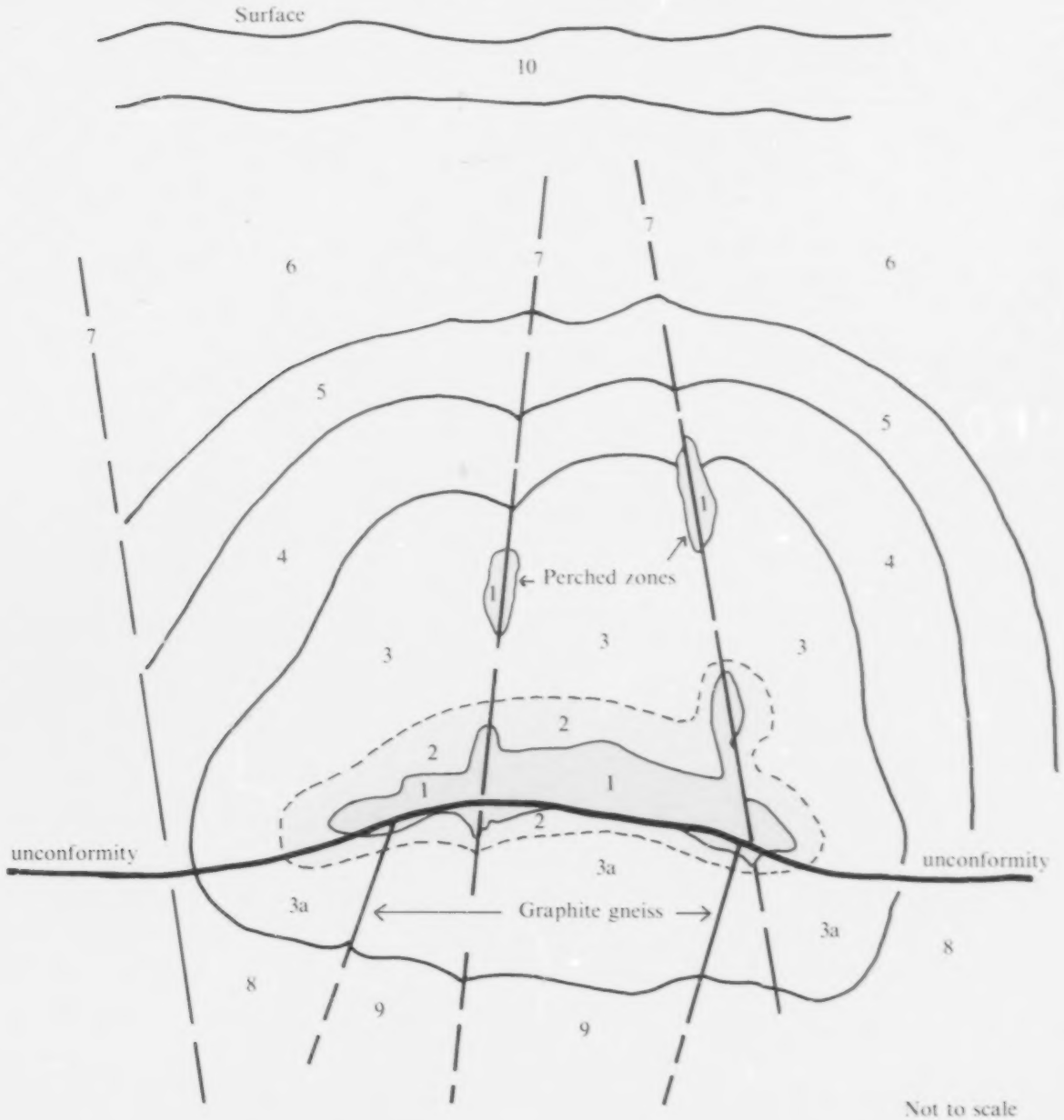
Figure 7. Typical north-south cross-section through the Cigar Lake uranium deposit. Note the relationship of altered zones to mineralization.



Not to scale

1. Zone of mineralization	6. Unaltered sandstone
2. Massive clay halo	7. Fault zone
3. Altered sandstone (quartz-free)	8. Metapelites
3a. Altered basement	9. Graphite Augen Gneiss
4. Quartz zone	10. Glacial material
5. Altered sandstone (iron sulfides)	

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arsenic. It is likely that none of the companion minerals occur in percentages high enough to be considered for recovery as a by-product to uranium. That option remains open, however, at least during the project planning stage.

Project Development

CLMC was established to formulate the best development method for exploitation of the Cigar Lake deposit. The present staff consists of the president, an accountant, a secretary, four mining engineers, one process engineer, and one environmental scientist. Each joint venture partner is represented. The staff performs studies of recovery plans based on existing technology; new and innovative ideas such as mining by remote control also are under consideration. In dealing with such high-grade ore, personnel safety and preservation of the environment take on even more importance than usual.

Project development probably will be timed to exploit two expected events:

1. The strengthening of the uranium market, which is anticipated in the early 1990s;
2. The phase-out of production at Key Lake, which could happen before the end of this century.

CMLC's flexible development schedule for Cigar Lake would allow for a one to three-year advance or delay of the project should unforeseen events require.

CLMC has established a tentative annual production target of 12 million pounds U_3O_8, based on mining and milling about 100 tonnes of ore per day at an average grade of 15 percent U_3O_8. A high-cost, large-capacity, conventional mine and mill complex will not be required. CLMC's studies indicate that project development can be accomplished primarily through the modification and application of existing technology. Improvements in equipment and techniques can be applied when developed, but they probably will not be necessary, even in areas of radioactivity that may be encountered. The CLMC staff has the advantage of drawing on experience in other relatively high-grade operations. For example, Phase I at Cluff Lake processed an average grade of 35 percent U_3O_8, so it provided ample practical experience for the special materials handling and radiological controls problems associated with high-grade ore. Some basic measures that will be taken to reduce and control exposures are:

1. Pressurized cabs for mining equipment;
2. Air filters for miners;
3. Protective clothing;
4. Shielded equipment (e.g., trucks, mill equipment);
5. Ventilation network design based on once-through and age of air techniques;
6. Back-up ventilation systems in case of breakdowns;
7. Radiation protection training for the workers;
8. Intensive monitoring of both worker exposure and site radiation levels using a range of measuring instruments.

CLMC has identified four areas of primary concern that must be resolved before a final development plan can be submitted for approval.

1. **Rock properties:** The properties of the five altered zones differ in compressive strength and hydraulic conductivity, each of which is directly related to clay content. At Cigar Lake, the high clay content of a rock zone produces lower compressive strength, reduced permeability, and a low competency level. The rock tends to be forced into any opening, such as a drill hole or a mined opening. Numerous problems are anticipated with conventional underground mining in the altered formations; thus, some modification of conventional mining techniques will be required.

2. **Groundwater:** The hydraulic conductivity (permeability coefficient) of the altered rock is known to be low. The existing information regarding groundwater suggests that structural and alteration events have somewhat isolated the area of interest from normal recharge conditions. If so, favorable conditions exist for dewatering an access shaft site and the ore deposit before mine development begins. Regardless, the implementation of a dewatering program which would require the drilling of strategically located wells within the isolated area is now under study. It appears that extremely large volumes of water would have to be pumped to accomplish the dewatering task. It may prove to be an enormous and costly task, one that would affect the selection of a mining method.

3. **Radiation control:** The high-grade ore at Cigar Lake presents a new challenge in radiation control, even considering similar problems once encountered in the mines at Key Lake and Cluff Lake. (The most significant difference between Cigar Lake and the other deposits is that Key Lake and Cluff Lake are both open-pit mines; average ore grades there, while high, are still lower than at Cigar Lake, which will be mined by underground methods.) A principal hazard to underground uranium miners is internal exposure to alpha and beta radiation emitted from airborne radon daughter products and external exposure to ionizing radiation from gamma rays. (Radon daughters concentrate in lung tissue, while gamma rays irradiate the whole body.) Some radon gas is present everywhere in the atmosphere because uranium, being a

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very common element, is present in at least trace amounts virtually everywhere. Usually the radon gas disperses harmlessly into the atmosphere. However, where uranium is present in large concentrations, the level of radon gas (and its daughters) in the atmosphere is far higher and can be hazardous to health. For occupational safety purposes, radon gas exposure is measured in *working level months*, derived as the product of average level of radon gas and the equivalent number of exposure months. The immediate problem at Cigar Lake is to anticipate the level of radiation at each phase of mining and milling. Subsequently, methods for controlling the radiation, such as shielding or containerization, can be implemented. Operational data available from working models adapted and applied at Key Lake and Cluff Lake have indicated that accurate predictions of radiation levels, and acceptable engineering solutions, can be achieved. Studies continue on radiation control problems at Cigar Lake, the results of which will determine the final development plans adopted by CLMC.

4. **Clay content:** In addition to lower strength and competency levels, the high clay content in the ore zone and surrounding altered rocks also compounds ore and waste handling problems. Underground, the clay-bearing material tends to build up on walls of ore cars, chutes, transfer points, and storage bins. Manual labor is required to normalize the flow of ore, and in so doing, the workers may be exposed temporarily to excessive levels of radiation. In addition, mechanized equipment used for moving ore and waste from point to point on the surface becomes coated with clayey material, requiring continual cleaning by shovelling or washing. In the latter case, a separate slimes settling and handling system may be required. Radiation exposure levels can be hazardous to workers in either case. The Cigar Lake project will have a number of clay-induced problems, many of which will need to be eliminated during the pre-engineering and planning processes.

Mine Planning

The final mining plan probably will combine conventional procedures, augmented by techniques designed to overcome the special circumstances of high-grade ore and unstable ground conditions. Conventional mining methods are favored because of experience and equipment availability. Access to the ore deposit will probably be through a conventional shaft sunk in barren ground with haulageways driven into or adjacent to the area of mineralization. Any attempt to mine the deposit strictly by conventional methods (e.g., stope or room and pillar), where miners must work close to high-grade ore, could create a difficult radiation control problem. In addition, rock instability would be a constant problem, necessitating the dewatering of all ground adjacent to the mine area, as well as either grouting or freezing the ground prior to initial excavation work. Freezing is a viable technique for shaft sinking, but freezing and then mining the ore deposit is a more difficult task. Grouting also has drawbacks; it is a costly process, and may be ineffective because the high clay content and low hydraulic conductivity of the rock would inhibit penetration.

Aside from conventional mining methods, there are four basic procedures under consideration for exploiting the Cigar Lake deposit:

1. **Raise borehole mining** can be implemented through the full use of conventional techniques. Access to the ore deposit is through barren ground, with development drifting completed above and below the ore zone. Raise boreholes are installed between the working drifts. Upreaming through the ore zone with a large-diameter bit drops the cuttings to the lower drift for loading and transporting to the surface; the fine material is slurried to the surface. Special ventilation controls the flow of air away from the loading area, which is the only location where miners are in close contact with ore. Miners could be further removed from contact with broken ore if remote-controlled mechanized units were used. Such units are already available for most phases of mining. Dewatering or freezing may be required for ground stability prior to actual mining of ore.

2. **Hydromilling mining** requires an access shaft and development drift to the area above the ore zone. A patented Hydrofraise tool occupies the drift as a metal frame designed to prevent caving while allowing mining. It is equipped with a vertical cutting drum which is used to drill through the ore zone, leaving a rectangular-shaped hole measuring about 1.5 meters by 2.5 meters. Cuttings are slurried from the cutting face to the surface for further processing. The Hydrofraise tool is advanced after each cut to complete mining of a predetermined slice. As each slice is made, it is immediately backfilled with concrete to prevent caving. The advantages of this remote-controlled mining method include slurry pumping to the surface and radiation protection for the miners.

3. **Borehole hydraulic mining** is a technique developed and tested by Flow Industries. The concept is based on down-the-hole erosion of an ore zone by the washing action of a high-pressure stream of water. The jet stream is created by a high-pressure nozzle attached to a compartmentalized pipe stem lowered through a drill hole

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into an ore zone. One compartment carries the water for jetting, another for pumping the cuttings to the surface. The nozzle can be turned 360 degrees and raised or lowered to mine all ore within a zone of influence. Effectiveness of the tool depends primarily on the character of the rock; the jet stream can be adjusted to cut and erode almost any type of rock, but with varying degrees of efficiency. The drilling and pumping units could be modified for underground access from a drift above the ore deposit if desired. This mining method would allow almost complete radiation control, but disadvantages include potential problems stemming from fragmentation of the high clay zones, control of cavern geometry, and possible ore losses due to uncontrolled caving.

4. **In-situ leach mining** has limited potential at Cigar Lake, but it is nevertheless under serious study. Obvious problems include the fact that the clay ore zone is relatively impermeable and may not accept induced lixiviant at an exposure rate required for proper leaching. Thus, recovery levels may be unacceptably low. The technique offers interesting advantages, however. The full range of equipment used for leaching could be adapted for underground operations from a drift above the ore zone, minimizing underground development work. Manpower requirements and material handling would be at a minimum, reducing the radiation hazards for miners. In addition, the disposal of waste material would be greatly eased and conventional backfill would be obviated. The planning committee may undertake in-situ leach testing in another location with similar geology to better demonstrate the viability of the technique under those conditions.

Pre-Development Schedule

With the formation of CLMC, the partners took the first step toward project development. The project will be operated by CLMC, while the joint owners will retain full financial and market responsibility. The organization is structured along the lines of the successful Key Lake Mining Corporation. At present, the CLMC staff is continuing studies dealing with environmental, radiation, geotechnical, and mine design concerns. Each study is a prerequisite for regulatory approval.

CLMC has declared 21 square kilometers surrounding the deposit as the area of operational control for the project, thereby isolating the Cigar Lake project from other activities on the remaining Waterbury Lake claim block. The completion of required studies will be followed by public review, after which CLMC presumably will receive permission from appropriate provincial and federal government agencies to proceed with project development. The 21-square-kilometer plot will probably be reclassified by the government from its present temporary-claim status to a lease extending through the project life. Technically, the lease serves as an instrument of conveyance with CLMC assuming full obligation to confine operations within the designated area, and to perform according to the terms and conditions established by provincial agencies. Upon accepting the lease, CLMC becomes obligated to operate the project under environmental and regulatory requirements of federal and provincial law.

The CLMC pre-development program is tentatively scheduled to complete all studies and secure regulatory approvals by the beginning of 1988. Test mining will continue until the end of 1989. Final development and feasibility planning will begin in 1987 and run through 1990, while actual mine development will begin about mid-1990 and continue until initial production begins about mid-1993. The schedule must remain flexible, so that final regulatory approvals can be secured and timing with future market opportunities can be exploited.

Acknowledgement

This article was made possible through the cooperation of CLMC. Additional information and concepts came from review of a paper presented on October 2, 1985 at the Atomic Industrial Forum Symposium, Santa Fe, New Mexico, and entitled: "The Cigar Lake project—concepts for mining high grade unconformity uranium ores, Athabasca Basin," prepared by Mr. Jean-Pierre Fouques, Chief Geologist, Cogema, and Mr. J. E. Tosney, Vice-President and Manager, Mining & Engineering, SMDC. Opinions, conclusions, and any errors are Nuexco's.

APPENDIX

Regional Geology

The uranium deposits of northern Saskatchewan have several common characteristics. Each deposit is associated with an unconformity separating two distinct rock types, and the source of mineralization is essentially the same. The rocks below the unconformity consist of Archean and Aphebian crystalline basement rocks belonging to the Wollaston Fold Belt series. Archean rocks include granites, biotite, and graphitic gneisses, as well as highly metamorphosed and altered sediments dated about 2,500 million years (m.y.). The fine-grained metasediments contain large quantities of graphite, often distinguishable as intercalated graphitic horizons. The graphitic gneiss zones contain abnormal amounts of uranium. The full rock sequence was folded, faulted, and meta-

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morphosed during the final stages of the Kenoran Orogeny, dated about 2,480 m.y.

Aphebian rocks of Lower Proterozoic age (about 1,850 to 1,700 m.y.) were deposited on the highly altered and eroded Archean surface as a thick series of sandstones, conglomerates, siltstones, and limestones, dispersed with a variety of volcanic rock flows. The sequence was subsequently highly metamorphosed, faulted, and infolded with Archean rocks during the Hodsonian Orogeny (about 1,735 m.y.). The metamorphic series consist of chlorite and graphitic gneisses, both of which are known to contain anomalous uranium mineralization. The upper portion of the Aphebian rocks was subjected to extensive weathering and alteration forming at the surface, the regolith mantle that varies in thickness from less than a meter to tens of meters. The regolith developed during the last stages of the Hodsonian Orogeny.

In unconformable contact with the Aphebian rocks lies the Athabasca Formation of Helikian age (Middle Proterozoic, over 1,350 m.y.). The Athabasca Formation consists primarily of quartzites derived from the upper portion of Aphebian rocks. It contains basal conglomerates and well-sorted and evenly bedded quartzites. The formation is about 1,650 to 1,700 meters thick in the center of the basin, thinning rapidly eastward to an erosional edge over the Wollaston Fold Belt series.

The source of mineralization probably started as abnormal amounts of uranium included in sediments of the Wollaston Fold Belt series, and consequently in the Athabasca Formation. Concentration of mineralization began with diagenesis of the Athabasca Formation and conditions of intense alteration and hydrothermal activity following Helikian deposition. Uranium was taken into solution by hydrothermal action, and later recrystallized as a reoccurring process. It eventually formed highly concentrated mineralization in the favorable host environment of the lower Athabasca Formation (and the upper regolith zone). At Cigar Lake, the course of alteration and hydrothermal activity appears to be much more complete, leading to the extremely high-grade ore accumulations. Mineralization shows the greatest concentrations along fault intersections in breccia and mylonite zones.

The Cigar Lake ore deposit is contained within the Manitou Falls Formation, which makes up the lower unit of the Athabasca sedimentary sequence. The Manitou Falls Formation contains four members designated in ascending order as A, B, C, and D. The main ore body is in the B member. The C member contains much of the perched ore, but the upper limit of mineralization extends to the D member. The A member is absent at Cigar Lake, but is present and well-mineralized at the Close Lake discovery about 17 kilometers to the southwest.

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RECENT DEVELOPMENTS

AUSTRALIA

Australian government officials and uranium producers are expressing quiet confidence about Australia's prospects for entering into significant long-term uranium supply contracts in the foreseeable future. Their reasoning is based on a relatively optimistic view of the short-term future for the uranium market, as follows:

1. International consumer confidence in South Africa could decline while political and social turmoil persists. As a result, Australia will become a more desirable source relative to other suppliers.

2. Supply from secondary sources will phase out over the next two years, causing buyers to turn again to primary producers for supply.

3. Demand for primary material will rise within the next two years, especially in Europe, due to increased economic activity and a re-emerging focus on long-term contracts.

4. Declining US primary production coupled with leveling Canadian exports will shift buyer attention increasingly to Australia as a long-term source. Canadian exports are expected to reach a plateau as new low-cost mines will begin to replace high-cost production in the domestic market.

To the extent that these perceptions materialize, the prospects of new sales improve for both Ranger and Roxby Downs. However, Roxby Downs still must overcome marketing obstacles to the achievement of its projected startup schedule, not only in uranium, but in the equally difficult copper market.

Consistent with a heightened sense of optimism in Australia, Roxby Downs and ERA (Energy Resources of Australia, the Ranger owners) evidently stepped up commercial activities in recent weeks.

1. ERA has announced two uranium contracts for a reported total value of US$190 million. It will supply Korea Electric Power Company and an unnamed US utility with approximately 6.3 million pounds U_3O_8. Deliveries are likely to commence in the early to mid-1990s. Since the contracts have received government approval, prices are expected to conform to the Australian floor price, currently frozen at US$31 per pound U_3O_8.

2. ERA has also announced its decision to expand production capacity approximately 10 million pounds (4,500 metric tons) U_3O_8 by 1988. Further expansion to 13 million pounds (6,000 metric tons) is likely to be under way by 1990. The original design and construction of the treatment plant made provision for a doubling of capacity, so this announcement has been expected for some time.

3. Olympic Dam/Roxby Downs partners have been trying hard to put in place uranium contracts before this December's anticipated date for commitment to project construction. In their view, the copper market poses no problem because the projected annual output of 55,000 metric tons is a very modest portion of the total market.

The optimism being expressed by the Australians must, however, be tempered by consideration of market realities. Foremost among them is the difficulty of executing a meaningful long-term contract when burdened by the government-imposed requirement for a floor price that is nearly twice the level of current spot market prices. Failing a substantial near-term increase in spot market prices, it is likely that consumers will continue to insist on contracts containing options or so-called walk-away provisions. While they may agree to token early deliveries at floor prices, buyers generally will not agree to pay well above spot prices for firm quantities over the entire life of a long-term contract.

* * *

ERA's Ranger mine, located in the Northern Territory, is taking precautions to ensure that its uranium production is not hampered by environmental conditions. At issue is its water management system and a strict "no release" policy dictated by the constraints of an environmentally sensitive area.

Because the mine is surrounded by the Kakadu National Park, specific environmental controls were attached to the mining lease. These included soil and vegetation cover conservation and restoration measures, and no release of water until practical release standards are developed and accepted by supervising authorities. Rainfall has been slightly greater than expected, and evaporation has been slightly less than expected. Thus, after five years of operation, the water management system is approaching capacity levels, storing almost 1.5 million cubic meters of water.

Ranger officials have implemented stopgap measures to give authorities time to consider the options. The use of stockpiled ore allows the mill to continue operating when the open pit is inaccessible due to excess water. Moreover, uranium deliveries have been maintained ahead of schedule. According to ERA, it has enough capacity to handle the next wet season, but some government sources believe the limits have been reached. In their view, only an early release of a substantial quantity of water will allow Ranger to establish another buffer stockpile during the next

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dry season to protect against production losses. However, discharging water from the Ranger catchment into the Magela River system is environmentally and politically sensitive, and repeated releases are especially unpopular. Aboriginal groups and Wildlife Services are opposed to any release of water. Ranger officials are aware that too much pressure for a once-only release, although helpful, could harm Ranger's prospects for obtaining an established water policy with better long-term operating flexibility. Although an interruption of production at Ranger, if it extended long enough, could further weaken Australia's reputation for supply reliability, the politically expedient solution might very well lead to that very eventuality.

* * *

The Australian government is considering its response to a proposal from Euratom to permit *origin swaps* (book transfers) of Australian-origin uranium. On two previous occasions Australia refused to approve such transfers. Because origin swaps had not been envisaged when Australia entered into bilateral agreements with user nations, a specific policy had not been developed, nor had the safeguards implications been examined. A recurring item in discussions with Euratom this year, this issue may now be close to a resolution after careful technical and political scrutiny, hopefully before the next consultative meeting with Euratom in December.

SOUTH AFRICA

Introduction

Last month's Report (#205, September 1985) discussed recent events associated with South Africa's mounting economic crisis, including the short-lived strike by the National Union of Mineworkers (NUM) and external pressure for reforms. Over the past weeks, pressure from the international community has continued, and on several occasions hopes have arisen that the Pretoria government would announce concrete reforms. The South African business community, by making direct contact with black leaders, has put pressure on the government to work out solutions to the civil unrest. However, Pretoria's concessions have yet to convince observers in either South Africa or the international community that real progress on the important issues is imminent.

Government Actions

In a series of four meetings of the ruling National Party in September, State President P.W. Botha announced vague offers of reform. The measures included in the offers, if fully implemented, might result in major changes in the apartheid structure. In mid-September, Botha declared that citizenship would be granted to those blacks who live in the segregated "homelands," and a presidential commission recommended the abolition of so-called pass laws, the regulations that restrict and control the movement of blacks throughout the country. At the end of the month, Botha designated his agenda for implementing such reforms as political rights for blacks, which could include an undefined vote.

Nevertheless, his remarks carried so many qualifications and contingencies that it is difficult to determine what effect the changes will have. Botha proposed continued segregation of schools and housing, stressing that the homelands would not be dismantled, and an aide clarified that citizenship for blacks did not imply political rights for those in the homelands. Consequently, black leaders condemned the ambivalent announcements and called for genuine reforms including power-sharing and an end to apartheid.

On October 2, Botha warned that he will not repeal the Group Areas Act, which prevents blacks, Indians, and persons of mixed race from living in white residential areas. It also forbids non-whites from owning property in white areas and assigns living areas to each racial group. The act, the pass laws, and the population registration laws, together form the basis of apartheid. Although a government commission has recommended the abolition of the pass laws, Botha's adamant refusal to repeal the Group Areas Act indicates the government's intransigence on the fundamental issues of apartheid.

International Reactions

Evidently unconvinced by Botha's earlier remarks, the European Community (EC), with the exception of Britain, in mid-September instituted limited sanctions against South Africa. Similar to the sanctions outlined in President Reagan's Executive Order of September 9, the EC sanctions for the most part reiterated restrictions already in force. Member states withdrew their military attaches from Pretoria, banned arms and oil sales, and halted nu-

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clear cooperation and sensitive technology sales. The sanctions were considered the maximum possible at the time in light of concerns about the large numbers of European citizens residing in South Africa. Two weeks later, after further study, Britain joined the EC in imposing sanctions.

In the USA, President Reagan presented a follow-up measure to his Executive Order by banning the importation of Krugerrand gold coins. Considered the most stringent sanction so far, in that South Africa derives half its foreign exchange earnings from Krugerrand sales, Reagan had promised to add the ban to the sanctions if such an action met little resistance from the General Agreement on Tariffs and Trade, a Swiss-based body that monitors world trading rules.

A bill was introduced in California that would have prohibited investor-owned public utilities from:

1. Selling or furnishing any nuclear, telecommunications, or alternative energy technology to South Africa;
2. Importing or using uranium of South African or Namibian origin for nuclear power plant operation.

The legislation, which had been under discussion for two months and passed in both houses of the California legislature, would have had no immediate impact on either of the state's investor-owned utilities. Nevertheless, the governor of California vetoed the bill. Plans to resurrect the bill or attempt to override the veto have not been announced.

South African Business Efforts

Business leaders are applying increasing pressure on the Pretoria government to institute reforms, and recently took measures to circumvent the government's handling of the matter. In mid-September, a group of businessmen met in secrecy with representatives of the outlawed African National Congress (ANC) to discuss the future of the country. The government condemned the meeting. However, in light of the increasing criticism of the government and concern over the falling value of the rand, the business leaders see themselves as ahead of the government in acknowledging that real reform, without conceding abrupt black rule, is vital to their interests and the country's economic welfare.

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PRIMARY MARKET CONVERTERS: ELDORADO

Introduction

Eldorado Resources Limited of Canada operates one of the five commercial uranium conversion plants in the western world.[1] Its facilities refine natural uranium concentrates (U_3O_8) to UO_3 at one location, and at another location convert the UO_3 either to UF_6 destined for eventual enrichment or to UO_2 for use in Canadian heavy-water (Candu) reactors. Its facilities also are capable of producing 2,500 metric tons of uranium metal per year. Eldorado Resources Ltd. is a wholly owned subsidiary of Eldorado Nuclear Ltd., a Canadian crown corporation whose other operations include uranium mining, milling, and exploration. Since 1980, Eldorado Resources Ltd. has invested C$250 million toward expanding its uranium processing and conversion facilities. In September 1983, a new uranium refinery began operation in Blind River, Ontario (Figure 8). The final stage of the expansion occurred during 1984 when construction of a new UF_6 conversion plant was completed at Port Hope, Ontario (Figure 9). The UF_6 plant capacity is twice that of the old Port Hope facility, but lower volumes of uranium feed have increased unit production costs at the new plant, and the worldwide excess of conversion capacity has led to market weakness. Table 1 lists total uranium processed by Eldorado since 1980.

Blind River Refinery

At the Blind River facility, uranium concentrates are refined into uranium trioxide (UO_3). The plant, commissioned in September 1983, has an annual capacity of 18,000 metric tons uranium (MTU). The refinery receives all types of concentrates, including diuranates of sodium, ammonium, and magnesium. Depending on the mineralogy of the orebody and the milling process used, impurities remaining in the concentrates vary widely. Subject to the conditions of standard acceptance specifications, those impurities are removed in the refining process.

The refining process begins with concentrate sampling to ensure accurate measurement of the concentrates received. Eldorado utilizes the auger method, in which an auger enclosed in a pipe is inserted into each of the 205-liter (approximately 55-gallon) drums of concentrates to remove a sample for analysis. The concentrates are measured for moisture content, uranium content, and impurities, as well as overall weight. Eldorado provides samples to the supplier for uranium determination. The analyses of the supplier and Eldorado are exchanged, and if the results differ by more than 0.21 percent uranium, an umpire analysis is initiated. The choice of umpire for uranium or impurity analysis is by mutual agreement between Eldorado and the supplier.

Following a sampling, the concentrates are blended to produce a uniform feed that reduces processing problems associated with the variations in the chemical properties of concentrates. Refining concentrates to UO_3 consists of the following steps, illustrated in Figure 10.

1. **Digestion**—The concentrates are added to a nitric acid solution in a cascade system, where the material is digested at 80° C. The acid reacts with the uranium in the concentrates to produce uranyl nitrate.

2. **Solvent Extraction**—The impure uranyl nitrate solution then enters an extraction column in which flows a solvent, tributyl phosphate (TBP). The TBP, diluted with kerosene to 25 percent, flows upward in the column as the impure uranyl nitrate flows downward, thereby extracting pure uranyl nitrate. Impurities and excess acid are discharged in the raffinate stream. Second and third columns wash the uranyl nitrate with water, where it separates from the TBP solvent, which is recycled. A pure uranyl nitrate solution, containing 10 percent uranyl nitrate and 90 percent water, flows to the evaporator. The nitric acid is recovered from the raffinate and the concentrated raffinate is returned to nearby uranium mills which recover the residual uranium.

3. **Evaporation**—The uranyl nitrate solution enters a series of three evaporators. The solution is heated to evaporate the water, and the uranium concentration is increased to 75 percent.

4. **Denitration**—The concentrated solution is fed into heated denitration vessels, where the remaining water

Table 1

TOTAL URANIUM PROCESSED AT ELDORADO 1980-84

Year	Production (MTU as UF_6 and natural UO_2)	Percent Change
1980	5,211	—
1981	5,990	+15
1982	6,339	+ 6
1983	5,564	-12
1984	4,399	-21

[1] The others are Allied Chemical, BNFL (British Nuclear Fuels Ltd.), Comurhex, and Sequoyah Fuels.

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Figure 8. The Blind River UO_3 refinery sits on the north shore of Lake Huron. The truck in foreground is unloading U_3O_8 for storage. UO_3 product is shipped from upper left end of the building.

Figure 9. The Port Hope UF_6 plant, located on the north shore of Lake Ontario about 70 miles east of Toronto. The active UF_6 plant is in the foreground, with the old plant directly behind it.

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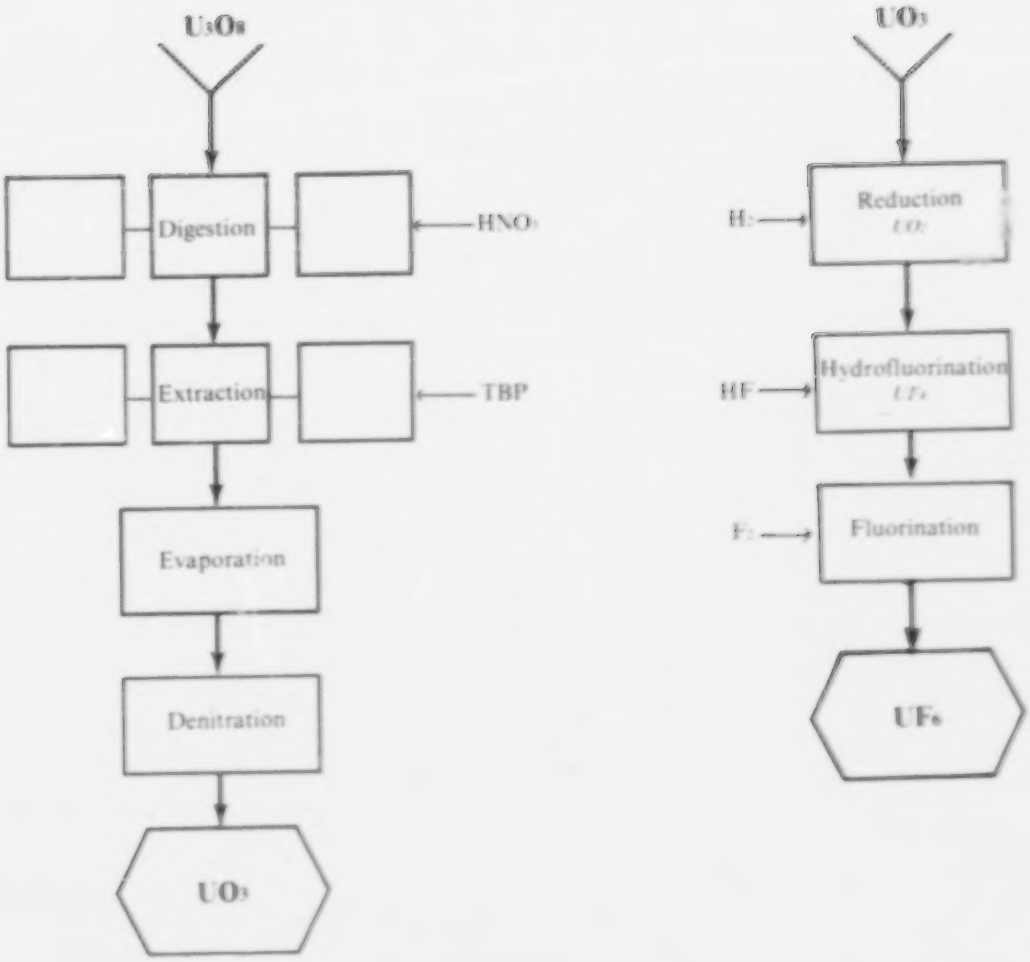

Figure 10. Blind River refining process, left, and Port Hope conversion process, right.

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evaporates and the uranyl nitrate thermally decomposes into uranium trioxide (UO_3) and gaseous nitrogen oxides. The nitrogen oxides are piped to an acid recovery process for eventual reuse, while the pure UO_3 powder is packed into 10-metric-ton bins for shipment by truck to the Port Hope facility (Figure 11). The trucks can carry three bins each.

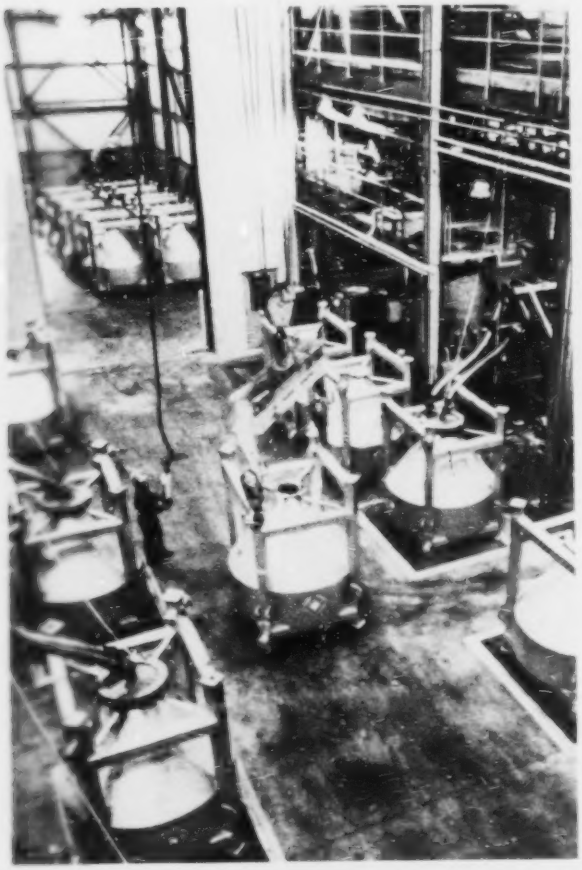

Figure 11. View of the UO_3 loading bay of the Blind River River refinery. UO_3 is loaded into 10-tonne containers for shipment to Port Hope.

Port Hope Conversion Facility

Most of the UO_3 produced at the Blind River facility is converted to uranium hexafluoride (UF_6) at Port Hope. At the new 9,000-MTU facility, the UO_3 powder is introduced into a fluid-bed-reduction reactor (Figure 10). The UO_3 is suspended in the reactor by hydrogen gas, which reduces the UO_3 to uranium dioxide (UO_2). The UO_2 powder is fed into wet reactors, where it is contacted with aqueous hydrofluoric acid (HF), which converts the UO_2 to uranium tetrafluoride (UF_4). The UF_4 is then filtered and dried before it is fluorinated in a flame reactor with fluorine gas (F_2) to produce UF_6. The fluorine is produced at the plant by means of the standard electrolytic process using 12,000-amp cells. The HF recovered from off-gas streams is recycled for the hydrofluorination process.

Cold traps (heat exchangers) cool and condense the gaseous UF_6 into white crystals. The solid is heated slightly to liquefy it, enabling it to be poured into 13-metric-ton steel shipping cylinders where it resolidifies. The material then is ready for shipment to enrichment plants in Europe and the USA.

Conversion to UO_2

Approximately 20 percent of the uranium Eldorado refines is converted to ceramic-grade uranium dioxide for use in Candu heavy-water reactors, which utilize natural uranium. The feed product used is pure uranyl nitrate, produced by dissolving the UO_3 end-product of the Blind River plant in nitric acid.

The uranyl nitrate is precipitated with ammonia to produce a slurry. Solid ammonium diuranate (ADU) is separated from the slurry, dried, and reduced with hydrogen in rotary kilns, producing ceramic-grade UO_2. The product is blended and packaged in 55-gallon drums for shipment to Canadian fuel fabricators. Ammonium nitrate recovered from the UO_2 process is sold as agricultural fertilizer.

The Blind River plant finished its first full year of operations in 1984, meeting the feed requirements of the Port Hope operations. Two factors, however, accounted for a 20-percent decline in total uranium processed by Eldorado in 1984.

1. The commissioning of the Port Hope plant resulted in lower than expected UF_6 production.
2. The shutdown for repairs of two reactors at Ontario Hydro's Pickering station reduced the need for ceramic-grade UO_2.

Several factors were involved in Eldorado's decision to begin expansion of its conversion facilities. In the mid-1970s, when forecasts indicated that rapidly increasing numbers of nuclear power plants would require greater conversion capacity, Eldorado officials determined that the old Port Hope facility was too small and outdated to continue to support a growing uranium production industry. Thus, plans for the Blind River facility emerged. In

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more recent years, assumptions that Canadian mine production would grow substantially and that the federal government upgrading requirement would remain in effect figured in the decision to expand capacity. Indeed, Canadian U_3O_8 production increased to approximately 29 million pounds in 1984, an increase of over 10 million pounds from 1983; Canada surpassed the USA in production for the first time to become the world's largest producer.

Although the Canadian government's upgrading requirement policy is still in effect, the government has granted numerous exemptions in recent years, especially to US utilities preferring U_3O_8. In such cases, utilities have been allowed to import Canadian U_3O_8 and convert it in the USA under existing contracts with US converters. (See Report 202, June 1985, page 24, for a discussion of the implications of US attempts to impose protectionist legislation aimed at Canada's upgrading policy.) The government considers exemptions provided certain conditions are met, and in recent months, exemptions under these conditions have been virtually automatic. Ultimately, in view of Canada's position as the world's leading uranium-producing country, the government probably will take a pragmatic approach to implementation of its upgrading policy to assure that the country's uranium sales are not unduly jeopardized. A Canadian government spokesman has indicated that the current review of uranium export policy will probably produce a more precise definition of the conditions under which exemptions will be granted.

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HISTORICAL MARKET DATA

EXCHANGE AND TRANSACTION VALUES SINCE JANUARY 1980

Determined as of the last day of the month indicated

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HISTORICAL EXCHANGE VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1968	—	—	—	—	—	—	—	6.35	6.35	6.40	6.45	6.50
1969	—	6.35	6.10	6.10	6.25	6.25	6.20	6.20	6.15	6.15	6.15	6.20
1970	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.20	6.15	6.15	6.15	6.15
1971	6.20	6.20	6.20	6.20	6.15	6.05	6.00	5.95	5.95	5.95	5.95	5.95
1972	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95
1973	5.95	6.00	6.10	6.20	6.45	6.50	6.50	6.50	6.50	6.50	6.75	7.00
1974	7.70	7.90	8.00	9.00	9.50	10.50	11.50	12.00	12.50	14.00	14.75	15.00
1975	16.00	16.00	18.00	20.00	21.00	23.00	24.70	26.00	26.00	28.50	30.00	35.00
1976	32.50	37.00	39.25	40.00	40.00	40.00	40.00	40.40	41.00	41.00	41.50	41.00
1977	41.35	41.50	41.60	41.60	42.00	42.25	42.25	42.25	42.40	42.75	43.20	43.20
1978	42.90	43.25	43.25	43.25	43.40	43.40	43.40	43.10	43.25	43.00	43.25	43.25
1979	43.25	43.25	43.25	43.25	43.25	43.00	42.70	42.70	42.20	42.20	41.00	40.75
1980	40.00	38.00	35.00	32.00	32.00	31.50	31.50	30.00	28.50	28.00	28.00	27.00
1981	25.00	25.00	25.00	25.00	25.00	24.25	23.50	23.50	23.50	23.50	23.50	23.50
1982	23.00	23.00	22.50	20.75	20.50	19.25	18.25	17.00	17.00	17.50	19.75	20.25
1983	21.50	21.75	22.25	23.25	23.50	23.50	24.00	24.00	24.00	23.50	22.50	22.00
1984	20.50	17.50	17.00	17.75	17.75	17.50	17.50	17.50	17.50	16.00	15.50	15.25
1985	15.00	15.00	15.00	14.25	15.00	15.00	15.75	16.00	**16.00**			

HISTORICAL TRANSACTION VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1976	—	—	—	—	39.60	39.70	39.70	40.40	40.30	40.60	40.70	40.70
1977	41.30	41.30	41.40	41.50	42.80	42.90	43.00	42.60	42.50	42.80	42.90	42.90
1978	43.10	43.30	43.70	43.60	43.60	43.20	43.30	43.40	43.40	43.60	43.40	43.70
1979	43.60	43.80	43.70	43.40	43.60	43.70	43.70	43.60	43.60	43.60	43.50	42.30
1980	42.00	39.30	38.60	38.40	37.90	37.60	37.30	31.60	30.60	29.00	28.70	27.70
1981	27.20	27.20	27.00	25.70	25.70	24.50	24.40	24.30	23.90	24.10	24.10	24.00
1982	24.00	23.70	23.40	22.60	22.70	21.50	20.30	19.10	17.30	17.00	17.55	18.80
1983	19.35	20.00	21.35	21.40	22.35	22.45	23.50	23.60	23.65	23.65	23.85	23.85
1984	23.05	22.50	19.25	17.90	17.00	16.50	16.60	16.40	16.55	16.05	15.90	15.90
1985	16.20	15.70	15.05	14.90	14.45	14.60	14.75	15.10	**15.10**			

HISTORICAL CONVERSION VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U as UF_6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1981	1.20	1.20	1.20	1.40	1.15	1.15	1.15	1.10	1.10	1.10	1.20	1.20
1982	1.20	1.20	1.20	1.20	1.00	1.00	1.00	0.90	1.10	1.60	1.45	1.45
1983	1.20	1.40	1.40	1.20	1.20	1.20	1.10	1.10	1.00	0.60	0.60	0.60
1984	0.60	0.30	0.80	0.80	0.80	0.00	0.00	0.80	1.00	1.00	0.80	0.80
1985	1.00	1.00	1.00	1.50	1.50	1.60	1.60	1.60	**1.60**			

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GOVERNMENT STATISTICS

AUSTRALIA

	Price Index of Materials Used in Manufacturing Industry—All Groups[1] (1969=100)	Award Rates of Pay Indexes Australia—Adult Males In Mining Wage and Salary Earners, Weekly Rates[2] (1976=100)
1983 Avg.	401.2	181.8
Jun 1984	404.7	197.4
Jul 1984	408.3	197.4
Aug 1984	413.1	197.4
Sep 1984	411.9	197.4
Oct 1984	408.4	197.4
Nov 1984	407.1	197.4
Dec 1984	405.9	197.4
Jan 1985	409.3	197.4
Feb 1985	416.0	197.4
Mar 1985	429.4	197.4
Apr 1985	440.2	202.3
May 1985	451.8	202.3
Jun 1985	—	202.4

P = Preliminary R = Revised since last month

CANADA

		Wage-earner Data: Average Hourly Earnings (C$)[2]					
	Industry Selling Price Index: Manufacturing[1] (1971=100)	Uranium Mines (SIC 057)	Metal Mines* (SIC 051-059)	Mines, Quarries and Oil Wells[3] (SIC 051-099)	Primary Metal Industries Non-ferrous[4] (SIC 296)	(SIC 298)	Chemicals and Chemical Products[5] (SIC 372-379)
1982 Avg.	298.8	—	**	14.30	—	—	11.17
Aug 1984	312.7	17.24	15.36	14.92	12.44	10.34	11.78
Sep 1984	312.3	17.68	15.96	15.34	12.51	10.52	11.90
Oct 1984	312.3	17.64	16.15	15.26	12.69	10.56	11.96
Nov 1984	313.6	18.04	16.13	15.43	12.47	10.51	11.96
Dec 1984	314.2	17.95	16.39	15.60	12.16	10.40	11.99
Jan 1985	315.8	18.05	16.13	15.60	12.32	10.80	12.04
Feb 1985	316.5	18.78	16.41	15.68	12.52R	11.05	12.06
Mar 1985	318.0R	18.24	16.21	15.57	12.43	10.97	12.02
Apr 1985	318.2	18.63	16.44	15.80	12.81	11.23	12.04
May 1985	318.8	19.41	16.51	15.63	12.76	11.25	12.15
Jun 1985	318.7R	18.49	16.20	15.49R	12.89	11.14R	12.14R
Jul 1985	318.9R	18.14P	15.99P	15.43P	13.00P	11.08P	12.14P
Aug 1985	318.8	—	—	—	—	—	—

P = Preliminary R = Revised since last month

For annual averages prior to 1983, and for notes pertaining to these statistics, see pages 23-26 of Report 190 of June 1984.

* The 1980 average for Metal Mines was incorrectly reported as 10.59. The correct average is 10.58 (see Report 190).

** Two different methods were used in the 1983 "Metal Mines" category in reporting survey data, and Statistics Canada did not publish a 1983 average. The March 1983 figure for the old method was 14.73 and for the new method was 14.84. The published average for 1983 in Report 190 was a Nuexco calculation based on the available monthly statistics for 1983 with the exception of the March figure, where only the 14.84 value was taken into account.

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GOVERNMENT STATISTICS

REPUBLIC OF SOUTH AFRICA

	Average Declared Working Costs per per Metric Ton of Gold Ore Milled (Rand)[1]	Tonnage-Weighted Index of Average Working Costs per Metric Ton of Gold Ore Milled (March 1982=100)[2]	Consumer Price Index[3] (1975=100)[4]	Producer Price Index All Groups[5] (1975=100)	Total Employment in Mining and Quarrying (Code 35)[6]	Total Salaries and Wages in Mining and Quarrying (1,000 Rand) (Code 40)[6]
1983 Avg.	51.87	115.0	262.2	274.8	696,579	3,644,772
Jun 1984	56.95	126.2	291.2	295.3	717,009	347,121
Jul 1984	—	—	295.1	296.0	717,121	369,964
Aug 1984	—	—	297.9	300.8	721,905	361,357
Sep 1984	60.64	133.2	299.9	304.1	721,470	359,218
Oct 1984	—	—	303.7	308.7	717,865	363,755
Nov 1984	—	—	307.4	312.8	717,396	369,771
Dec 1984	62.92	138.6	309.4	315.9	701,198	365,234
Jan 1985	—	—	177.1*	166.6*	711,366	376,777
Feb 1985	—	—	182.8*	171.3*	727,932	361,823
Mar 1985	64.48	142.4	183.6*	173.0*	708,809	371,380
Apr 1985	—	—	187.4*	174.0*	724,187	369,005
May 1985	—	—	189.5*	177.7*	708,085	373,478
Jun 1985	67.42	148.9	191.9*	179.2*	—	—
Jul 1985	—	—	193.6*	180.7*	—	—
Aug 1985	—	—	195.6*	—	—	—

* The basis for calculation for these indices has been revised to January 1980 = 100.

UNITED STATES

	Producer Price Index[1]		Consumer Price Index[2]	GNP Implicit Price Deflator[3]	Gross Average Hourly Earnings of Production or Non-supervisory Workers (US$)[4]			
	Industrial Commodities (1967=100)	All Commodities (1967=100)	(1967=100)	(1972=100)	Metal Mining (SIC 10)	Primary Non-ferrous Metals (SIC 333)	Chemicals and Allied Products (SIC 28)	Electric and Electronic Equipment (SIC 36)
1983 Avg.	315.8	303.1	298.4	215.63	12.57	13.43	10.59	8.65
Jul 1984	324.0	312.0	311.7	—	13.02	13.36	11.12	8.95
Aug 1984	323.5	310.9	313.0	—	13.10	13.51	11.13	9.00
Sep 1984	322.3	309.5	314.5	224.57	13.20	13.39	11.23	9.08
Oct 1984	323.2	309.4	315.3	—	13.23	13.53	11.32	9.09
Nov 1984	323.8	310.4	315.3	—	13.23	13.76	11.35	9.15
Dec 1984	323.0	309.9	315.5	226.10	13.28	13.66	11.37	9.27
Jan 1985	322.9	309.5	316.1	—	13.29	13.70	11.39	9.33
Feb 1985	322.5	309.2	317.4	—	13.30	13.73	11.39	9.33
Mar 1985	322.6	308.7	318.8	229.07	13.29	13.95	11.37	9.39
Apr 1985	323.8	309.3	320.1	—	13.43	13.62	11.48	9.40
May 1985	325.3	309.9	321.3	—	13.24	13.59	11.46	9.39
Jun 1985	324.7	309.1	322.3	230.55R	13.23R	13.66R	11.52R	9.46R
Jul 1985	324.3	309.0	322.8	—	13.45P	13.82P	11.60R	9.47R
Aug 1985	323.6	307.2	323.5	—	13.45P	13.70P	11.63P	9.52P

P = Preliminary R = Revised since last month

For annual averages prior to 1983, and for notes pertaining to these statistics, see pages 23-26 of Report 190 of June 1984.

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